Technical Note:

Gaens Quarry: Transitional abstraction licence (transfer and full) application

Published by Stantec UK Limited

September 2019

Document reference:

66664R1

Report status:

Final

CONFIDENTIAL

New Zealand House, 160-162 Abbey Foregate,
Shrewsbury, Shropshire
SY2 6FD

Telephone: +44 (0)1743 276 100

Registered Office:
Stantec UK Ltd
Buckingham Court
Kingsmead Business Park
Frederick Place, London Road
High Wycombe HP11 1JU
Registered in England No. 1188070

Prepared for TS Rees Limited

Document reference: 66664R1, September 2019

This report has been prepared by Stantec UK Ltd (Stantec) in its professional capacity as environmental specialists, with reasonable skill, care and diligence within the agreed scope and terms of contract and taking account of the manpower and resources devoted to it by agreement with its client and is provided by Stantec solely for the internal use of its client.

The advice and opinions in this report should be read and relied on only in the context of the report as a whole, taking account of the terms of reference agreed with the client. The findings are based on the information made available to Stantec at the date of the report (and will have been assumed to be correct) and on current UK standards, codes, technology and practices as at that time. They do not purport to include any manner of legal advice or opinion. New information or changes in conditions and regulatory requirements may occur in future, which will change the conclusions presented here.

This report is confidential to the client. The client may submit the report to regulatory bodies, where appropriate. Should the client wish to release this report to any other third party for that party's reliance, Stantec may, by prior written agreement, agree to such release, provided that it is acknowledged that Stantec accepts no responsibility of any nature to any third party to whom this report or any part thereof is made known. Stantec accepts no responsibility for any loss or damage incurred as a result, and the third party does not acquire any rights whatsoever, contractual or otherwise, against Stantec except as expressly agreed with Stantec in writing.

	Name	Signature
Author	Richard Holtham	R Holtham
Checked by	Kate Brady	Kate Brady
Reviewed by	Barnaby Harding	Barnaby Harding

Contents

1 Introduction

Gaens Quarry (the Site) is a limestone quarry situated to the east of the village of South Cornelly, some 0.5 km south of the M4 motorway, 2 km south of Pyle, and approximately 2 km north/northeast of Porthcawl. The Site is accessed off Porthcawl Road, South Cornelly, Near Bridgend, Wales and is located approximately at post code CF33 4RQ. A Site location plan is presented as Figure 1.1.

The Site is dewatered in order to facilitate the extraction of limestone. The base of the quarry is below water table and hence dewatering water contains both rainfall and groundwater components. Some of the dewatered water is used at the Site for a variety of associated processes.

This Technical Note has been prepared by Stantec UK Limited (Stantec) to support an application on behalf of T.S. Rees Limited (TS Rees) to obtain transitional route transfer and full abstraction licences for the dewatering of Gaens Quarry and various water use activities and should be read in conjunction with the following application forms presented in Appendix A:

- Form WRH: Application for a transitional water resources licence - Transfer; and
- Form WRH: Application for a transitional water resources licence – Full.

The forms are signed on behalf of TS Rees by Sam Rees who is an authorised signatory. A letter of authorisation accompanies the form in Appendix A.

Payment of the combined application fee of £1,635 (£1500 for the transfer component and £135 for the full component) will be paid by credit card.

Per application form question 2.4, invoices should be addressed to:

Mr Sam Rees,
Gaens Quarry
South Cornelly
Pyle
Bridgend
Glamorgan
CF33 4RD
tsreesltd@btconnect.com
tel: 01656 748808

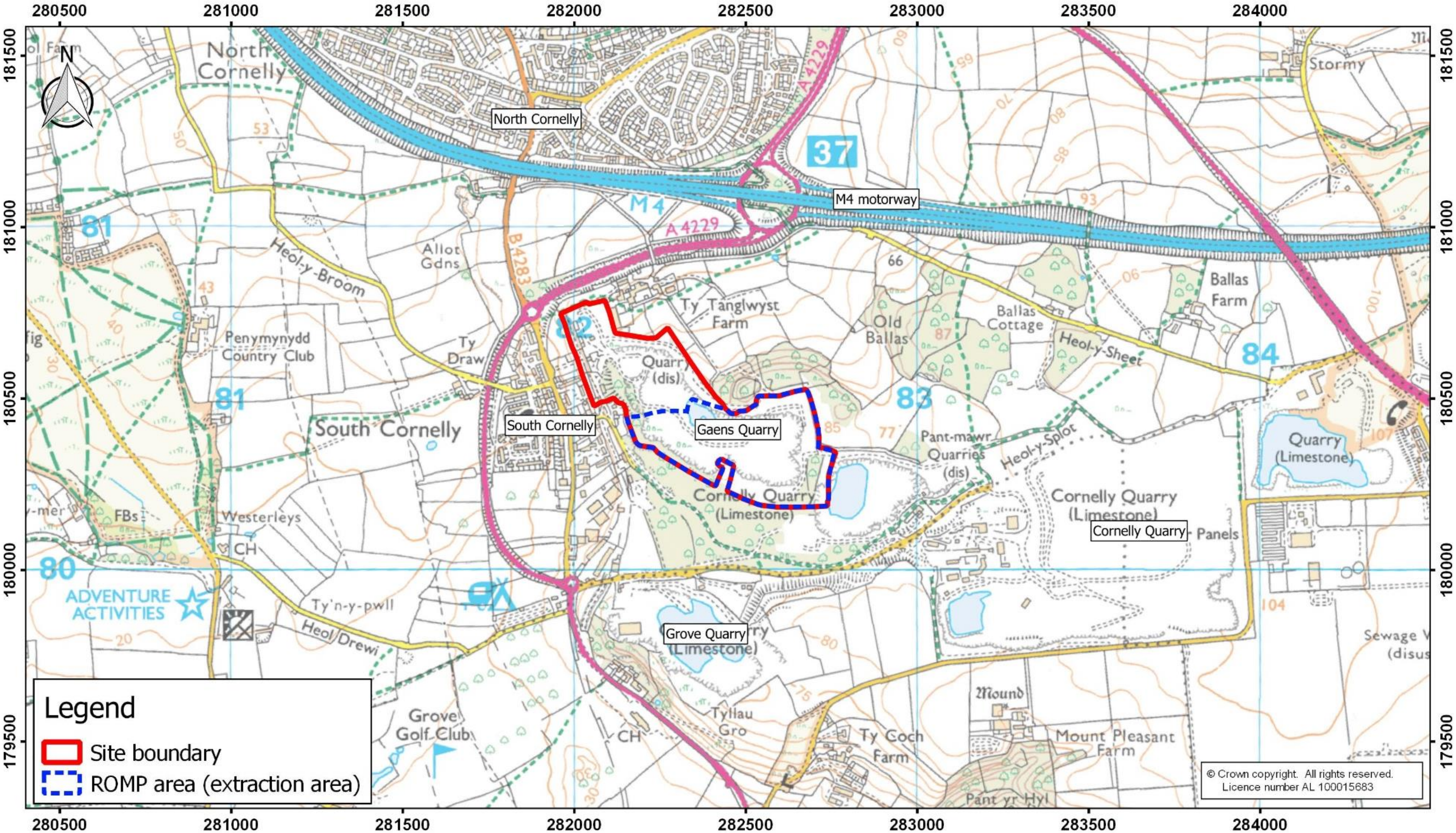
1.1 Background

Gaens Quarry is a limestone quarry in Wales, producing approximately 180,000 tonnes of limestone aggregate per year, principally for the construction industry. The total area covered by existing consents for mineral extraction at the Quarry is approximately 15 ha while the area where mineral extraction is currently undertaken is closer to 3 ha. The main quarry floor is currently at around 0 mAOD at its deepest point. The Site is dewatered by pumping water out of the quarry sump and transferring to a soakaway located within the site boundary. Over the next c.10-15 years, the Quarry will be worked to c.-20 mAOD.

Quarrying at Gaens commenced in the early 1900s and was formalised by an Interim Development Order (IDO) permission granted in 1948. Gaens Quarry was acquired by TS Rees Ltd in 1982. The current planning (ROMP) permission is provided in Appendix B.

Gaens Quarry is located adjacent to Cornelly Quarry and Grove Quarry (northwest and north of the Site respectively). Cornelly and Grove quarries are both operated by Tarmac Trading Limited. Cornelly Quarry is dewatered to c.-3 mAOD and discharges to Grove Quarry. Groundwater levels at the Site will be influenced by the dewatering and discharge operations at these two quarries.

Figure 1.1 Gaens location and owner/occupier boundary



1.2 Planning permission

Planning permission for the Site exists in the form of ROMP permission (A-PAA-25-08-004), granted on 22 December 2016. A copy of the ROMP permission/decision notice is presented in Appendix B.

1.3 Environmental Statement

As part of the ROMP process, a voluntary Environmental Statement (ES) (SLR, 2014) was produced. The relevant hydrogeology and hydrology sections were prepared by Stantec (formally ESI Ltd). The impacts identified on the water environment from the proposed development of Gaens Quarry are, in general, minor.

The main points from the EIA are summarised below and a copy of the most relevant sections is provided in Appendix C.

1. Small predicted hydrogeological effects but no significant hydrogeological impact on Kenfig Pool and Dunes or Merthyr Mawr SSSIs. Cefn Cribwr discounted due to lack of effective hydrological pathway. The nature of the connections and sensitivity of the groundwater levels have been well-constrained through further investigation and integrated numerical modelling.
2. Predicted impacts on the local hydrology are minor. Some effects but no significant impacts predicted for the 24 potentially vulnerable receptors. The likelihood of encountering a significant interconnected fissure at depth has been considered in detail and is concluded to be very low. The implications of encountering such a feature (if one did exist) have been considered by means of modelling which has informed the development of a Water management Plan (WMP) (Appendix D) for the site to tackle this residual uncertainty. The modelling work shows that the timescales for the effects of encountering such a feature to manifest themselves at key receptors are such that the proposed monitoring would provide sufficient warning to allow effective mitigation to be put in place.
3. Regarding the potential impacts on other groundwater users and water features in the area, see 2.
4. There is no significant risk of saline intrusion predicted.
5. Further deepening of Cornelly Quarry will steepen the hydraulic gradient between adjacent landfills and Gaens Quarry. However, careful consideration of this issue indicates that this does not represent a significant risk. The Water Management Plan includes measures to monitor the quality of water pumped from the quarry sump.
6. It is not anticipated that the proposed discharge will cause any localised concentration of groundwater flow that could cause washout and hence there are no localised effects on ground stability.
7. It is not anticipated that the proposed discharge will cause any localised concentration of groundwater flow that could cause sinkhole development.

The potential and residual risks have been addressed by means of a monitor and mitigate strategy embedded in the current WMP for the Site, provided as Appendix D. The WMP has previously been subject to extensive consultation with the regulators since 2001.

1.4 Collection and review of monitoring data

As required by the WMP for Gaens and the other two Cornelly quarries, monitoring data are collected from a large number of locations at and around the Site, typically on a monthly basis. This includes monthly quality testing of the groundwater in the sump. Review of these data is presented to the planning authority and Natural Resources Wales (NRW) twice a year in the form of Interim and Annual Reports. These reviews include an assessment of any observed effects of the quarry dewatering on the water environment, breaches of trigger levels, and recommendations for mitigation.

1.5 Report structure

This technical note covers the details required by the application forms and includes:

- Existing water movements and water management at the Site, including abstraction arrangements, water use details, and transfer/discharge details (Section 2); and
- Licencing requirements summary (Section 3).

2 Water Management

2.1 Site water management

Dewatering is required to facilitate efficient extraction of the mineral. During quarrying operations, run-off from the Site and groundwater ingress will accumulate within the lowest section of the active quarry void (the sump), see Figure 2.2. Dewatering occurs to around 0 mAOD.

The Site is governed by the WMP which provides full detail of the monitoring, reporting, and other water management requirements. A copy is provided in Appendix D.

Modelling undertaken for the ES (SLR, 2014), predicted average off-site pumping rates of 2,443 m^3/d with a quarry base at 0 mAOD (or approximately 15 years into the development) and 2,353 m^3/d at -20 mAOD (or approximately 42 years into the development); demonstrating that inflows are not expected to dramatically increase with depth.

These rates assumed that Cornelly Quarry continues to discharge primarily to Grove Quarry. If Cornelly Quarry reverts to pumping to Pant Mawr quarry, then the rate required to dewater Gaens Quarry will increase.

The EIA acknowledged that the predicted rates are off-site rates and do not take into account recirculation that occurs where water is discharged close to the quarry sump, i.e. the soakaway lagoon. The occurrence of recirculation has minimal impact on the flows within the aquifer outside the sump and lagoon area but does result in a higher pumping rate from the sump itself. The abstraction was not metered during the qualification period, but a meter has subsequently been installed and dewatering records from May 2018 to November 2018 show average daily pumping rates from the sump were 544 m^3/day, with a calculated range of 150-4,100 m^3/d, which bounds the predicted volumes.

2.2 Abstraction arrangements

The water management arrangement for the Site is presented schematically in Figure 2.1 and Figure 2.2. Figure 2.3 shows a cross section of the Site now and in the future.

A Godwin HL100M Dri Prime pump is used to pump water from quarry void, with a maximum flow rate of 60 l/s. This water is transported in overground pipes that head west to the soakaway lagoon and then, when required, on to the western part of the Site where bowsers are filled for use. When the water is required for use, the end of the discharge line at the soakaway lagoon is connected to a second set of pipework which takes the water up toward the processing area. When use is complete the extension line is disconnected and discharge to the lagoon resumes. Photographs of the pump are shown in Plates 1 to 3.

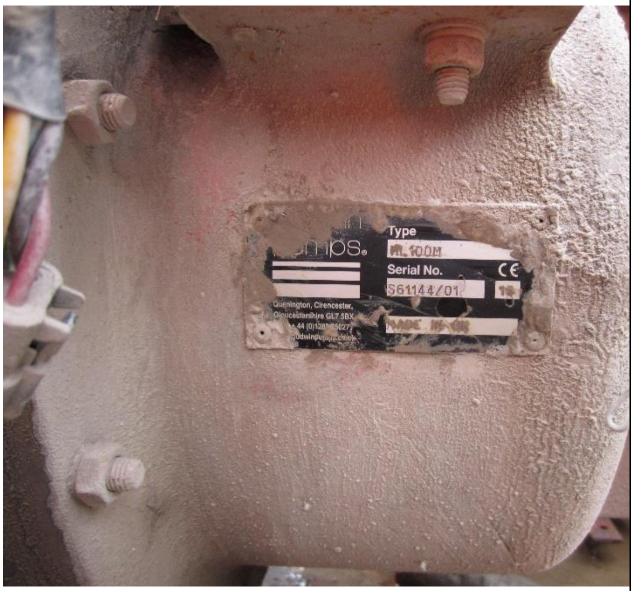


Plate 1: Sump pum serial number

Plate 2: Sump pump meter

Plate 3: Sump pump in quarry void

A meter located upstream of the lagoon discharge and extension line connection point (water use) records the flow volume from the pump, covering both the transfer volumes and usage volumes (when usage occurs). Meter readings are taken approximately twice weekly. No data is available for the reporting period 2011 to 2017.

During this time, meters were manually read, meaning that measurements are available for varying time periods, but these have been calculated as daily averages (see Appendix E).

Total abstracted volumes for the metered period in 2018 are given in Table 2.1.

Table 2.1 Metered abstraction volumes, Gaens Quarry - 2018

Period	Calculated annual abstraction (m^3)[a]	Maximum calculated daily abstraction (m^3)[b]	Maximum hourly abstraction rate (m^3/hr)[c]	Maximum instantaneous pumping rate (l/s)[D]
2018	656,700	4,100	216	60

a. Based on the measured data from May 2018 to November 2018 plus the remaining days of the year at the maximum daily abstraction rate recorded (4,100 m^3). Assumes 5.6 working days a week

b. Metered maximum daily rate (August 2018)

c. Maximum pump rate (60 l/s) for one hour

d. Maximum abstraction rate of the pump

Figure 2.1 Water movements schematic

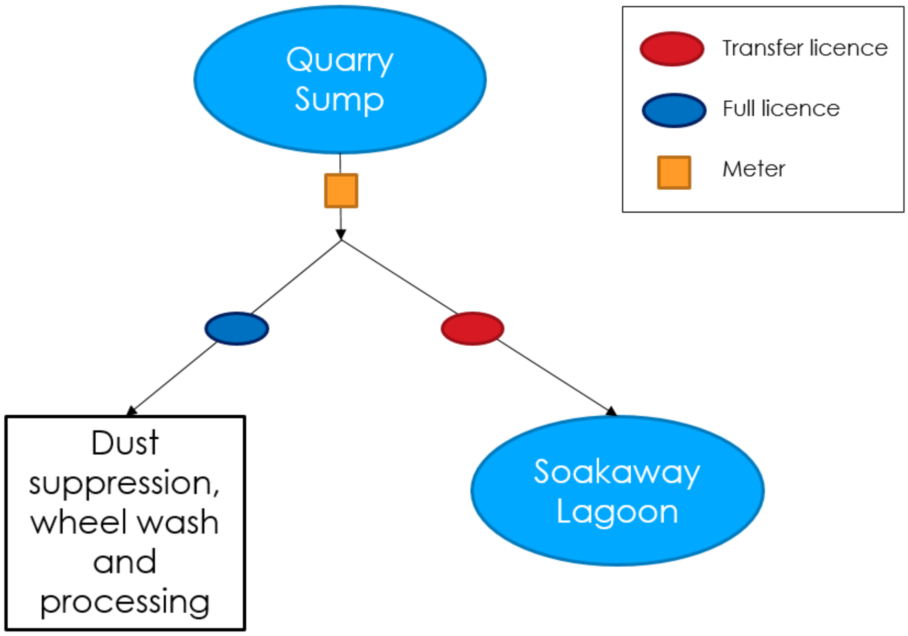


Figure 2.2 Water management plan

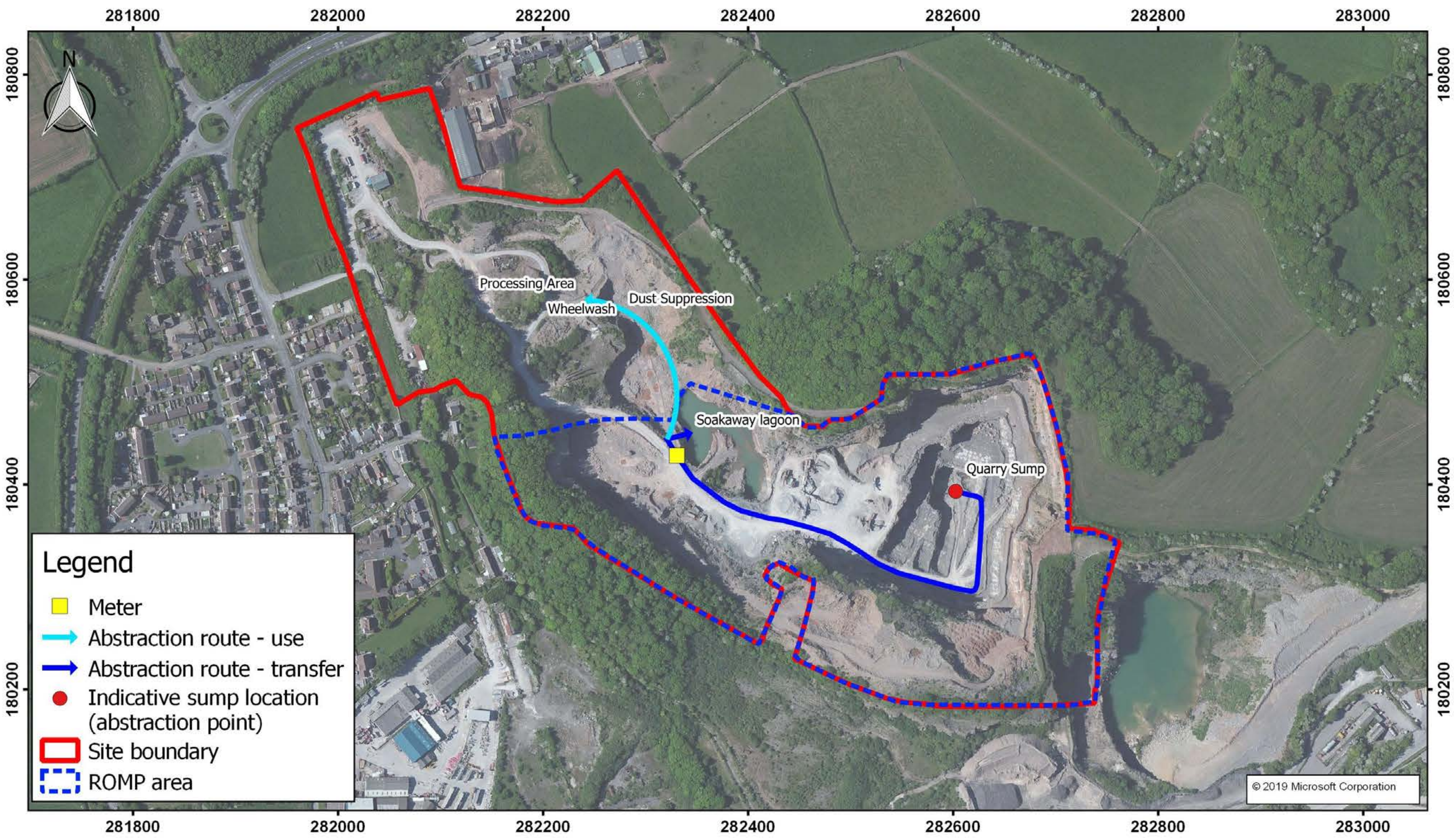
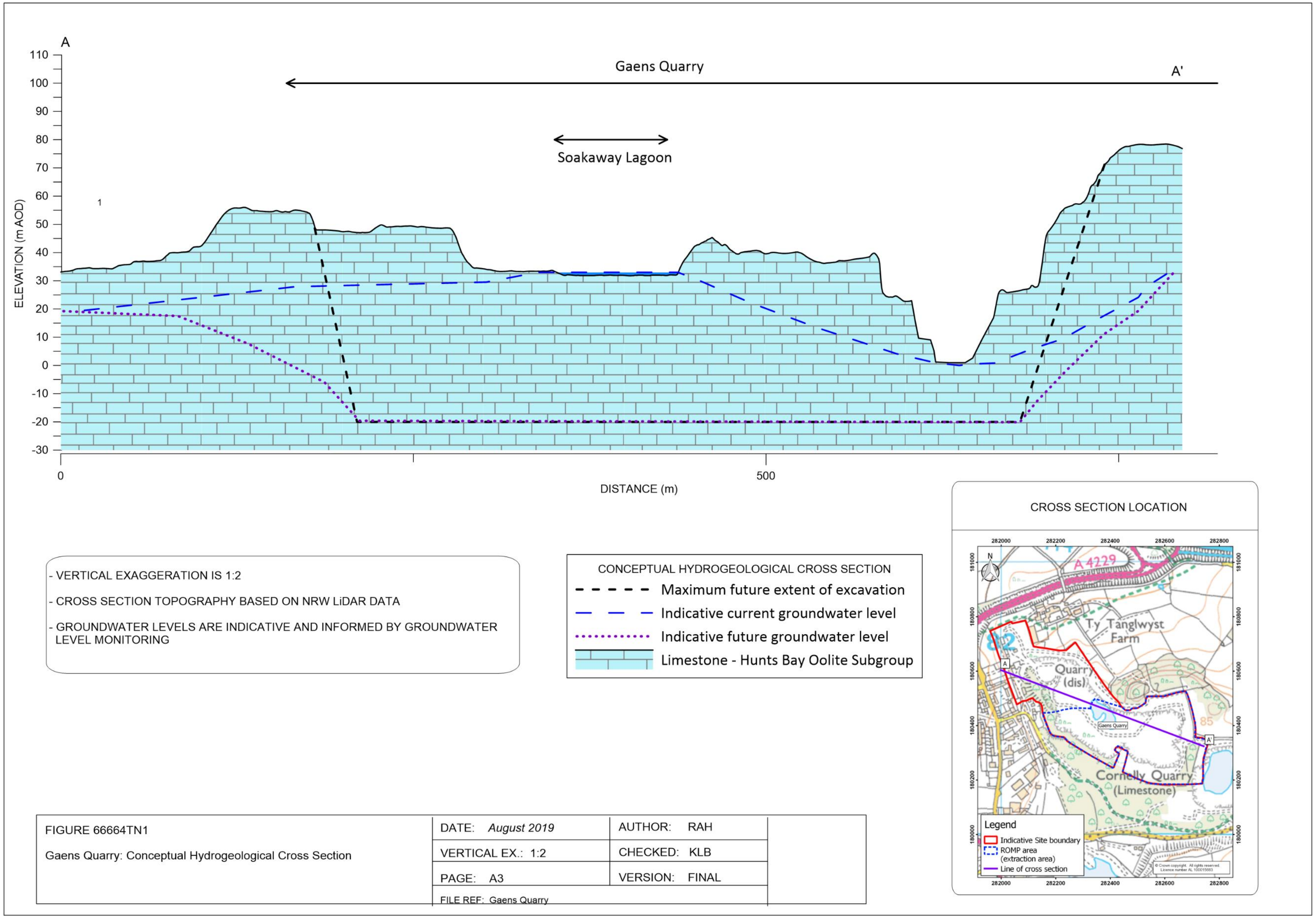


Figure 2.3 Cross section



2.3 Water use

Abstracted water is used for the following on site activities:

- Dust suppression;
- Wheel washing; and
- Mineral processing.

Water use volumes have been calculated based on testimony from Site staff e.g. number of bowsers used for the different processes. These presumptions are detailed in the bullet points below. Maximum hourly and instantaneous rates for all processes is based on the maximum flow rate of the pump.

- Dust suppression during the summer (April to August) has been estimated based on using three bowsers of water per hour, continuously (for nine hours each day). Bowser capacity is 5000 litres (l). No dust suppression is carried out in the winter due to generally damp/wet weather conditions negating the need for active dust suppression.
- The wheel wash is operated using water recycled from the wheel wash storage tank (capacity 25,000 l). It is estimated that the wheel wash is topped up using approximately two bowsers each week. The tank is also cleaned out every 1.5 weeks (site staff estimated it is emptied every 1 to 2 weeks). The maximum daily usage is therefore the day that the tank is emptied and refilled (25 m^3).
- Mineral processing usage is based on an annual extraction quantity of 180,000 tonnes of mineral per year and a usage of 0.02 m^3 of water per tonne of mineral (Based on EA, 2003).

Table 2.2 Water use estimates

Use	Annual usage (m^3)	Maximum daily usage (m^3)	Maximum annual hourly abstraction rate (m^3/hr)	Maximum instantaneous abstraction rate (l/s)
Dust suppression	23,550	135	135	60
Wheel wash	1,395	25	25	60
Mineral processing	3,600	12	12	60
Total	**32,445**	**172**	**172**	**60**

2.4 Transfer/discharge

Prior to May 2018, volumes abstracted from the sump were not metered. Meter readings of water abstracted from the sump are available from May to November 2018. This information is considered to be representative of the pumping activities undertaken during the qualifying period 2011 to 2017 (without consideration of annual rainfall variations). The readings from the meter are taken at varying time intervals from 1 day to 14 days.

No water is discharged off site. Abstracted water is either used for on Site processes or is transferred to the soakaway lagoon in the centre of the Site. This water than infiltrates to ground. The quantity of water discharged to the soakaway lagoon is not directly metered, but has been estimated by taking away the estimated water usage from the estimated quantity of water abstracted from the quarry sump. This is outlined in Section 3.

3 Licencing requirements summary

Dewatering is required to facilitate working of the mineral in a dry condition. A transitional route abstraction (transfer) licence is required to continue this work. Water from dewatering is also used in on-site processes, which requires a transitional (full) licence.

Table 3.1 presents the volumes to be licenced based on available information. More detail on the means of calculation are provided in the previous section of this report and in Appendix E.

The meter readings on which the calculations are based are submitted on a six-monthly basis to NRW and Bridgend Council in accordance with the WMP.

Table 3.1 Calculated volumes abstracted and used

Licence type	Maximum (m^3/year)	Maximum (m^3/day)	Max (m^3/hour)[C]	Max instantaneous flow (l/s)[C]
Full licence [a]	28,545	172	172	60
Transfer licence [b]	628,155	3,928	216	60

A Calculated (see section 2.3)

B Total abstracted quantity minus the water use, equal to max pump rate which is lower than the calculated abstraction rate.

C Pump capacity

References

SLR, 2014. Environmental Statement Volume 1, Environment Act ROMP Review: Gaens Quarry.

Appendices

Appendix A

Application forms

Application for a transitional water resources licence

Form WRH

Fill in this form if you are applying for a transitional water resources licence to continue a previously exempt abstraction.

This form is available in both English and Welsh. Please check that this is the latest version of the form available from our website before submitting your application.

Please ensure you use Guidance Note WRH to help you.

All relevant guidance documents can be found on our website.

Contents

1. Application type and fee

1.1 Please select your application type from the list below.

A new transitional water resources full abstraction licence for a previously exempt abstraction	☐
A new transitional water resources transfer licence for a previously exempt abstraction	☑
A variation to an existing full abstraction licence to add a previously exempt abstraction	☐
A variation to an existing transfer licence to add a previously exempt abstraction	☐

1.2 Please indicate the amount and how you wish to pay your application

Amount paid	1500		
Cheque	☑		
Credit or debit card	☐		
BACS transfer	☐	BACS reference number	PRC

2 Applicant and agent details

This is the individual or organisation any resulting licence will be issued to, and must be a legal entity. If you are an agent acting on behalf of an applicant, provide their details here and yours in section 2.2.

2.1 Applicant details

Individual	☐	Public body	☐
Registered company	☑	Organisation or group of individuals	☐
Other	☐	If 'Other', please specify	

Title: Mr

First name	Sam
Last name	Rees
Company, charity, body, or trading name (if relevant)	
Registered company or charity number (if relevant)	TS Rees Limited
Address	Cornelly Quarries
	Pyle
	Glam
Postcode	CF33 4RD
Telephone - mobile	
Telephone - office	
Email address	tsreesltd@btconnect.com

We will contact you by email unless you tick here. ☐

2.2 Agent details

This is who we will correspond with unless otherwise informed. If you are an agent applying on behalf of an applicant, please include a letter of authorisation from the applicant allowing you to act as signatory,and provide a reference for this document in the box below.

Document reference		
Title	Ms	
First name	Kate	
Last name	Brady	
Company or trading name	Stantec UK Ltd	
Position in company	Senior Consultant	
Address	New Zealand House	
	160 Abbey Foregate	

	Shrewsbury
	Shropshire
Postcode	SY2 6FD
Telephone - mobile	07376 497250
Telephone - office	01743 276117
Email address	kate.brady@stantec.com

We will contact you by email unless you tick here. ☐

2.3 Site operation contact

Please specify who we should contact with regard to your site operation.

Applicant ☐

Agent ☑

Other ☐ Please provide contact details for the operational contact on a separate referenced document, and tell us this reference below.

Document reference

2.4 Abstraction invoices and records contact

Please specify who we should contact for invoices and abstraction records (returns). Please note that these may not be not required for transfer licences.

Invoice address

Applicant ☑

Agent ☐

Other ☐ Please provide contact details for the operational contact on a separate referenced document, and tell us this reference below.

Document reference

Abstraction records

Applicant ☑

Agent ☐

Other ☐ Please provide contact details for the operational contact on a separate referenced document, and tell us this reference below.

Document reference

3. Site name

3.1 Please provide the site name below:

Site name: Gaens Quarry

4. Entitlement to apply

4.1 Have you abstracted water between 01 January 2011 and 31 December 2017 for the activity which you are applying to be licensed?

Yes ☑

No ☐ Please see our water abstraction and impounding webpage for further information on the correct applicaton forms.

4.2 What is your connection to the land where the abstraction takes place?

Please provide a map outlining your land ownership/occupation and include all abstractions and discharges where relevant.

Owner ☑

Occupier ☐

Document reference: Red line in Fig 1.1 of report 66664TN1

4.3 Do you have a legal right of access to the land where the abstraction take place?

No ☐

Yes ☑ Please provide further detail in the box below. If necessary continue on a separate referenced document, and tell us this reference.

Document reference: ROMP permission

See Appendix B of report 66664TN1

5. Existing licence number(s)

If you are applying to change an existing licence please provide the licence number below.

Licence number(s): n/a

6. Cross border applications

As part of your site operation do you also abstract for a previously exempt activity in England?

No ☑

Yes ☐ Please provide detail of this cross border application in the box below. If possible, provide a reference or application number, or name of an Environment Agency contact with whom the application has been discussed.

Continue on a separate referenced sheet if necessary and tell us the reference for this document.

Document reference:

7. Abstraction details

7.1 Site map

Please provide a map with details of the location(s) you abstract water from (points reaches, or areas). Tell us the reference for this map, below.

Site map reference	See report 66664TN1, Figure 2.2

7.2 Please tell us details about the location(s) you abstract water from (points reaches, or areas) in the tables below.

The abstraction location, name, or reference must be the same as those used on the site map, in question 7.1. If you need more space, please continue on a separate referenced sheet if necessary and tell us the reference for this document

Document reference	ROMP Area in Figure 2.2 in 66664TN1

Table 7. 1 - Surface water abstractions						
Abstraction location name or reference (As labelled on the site map)	Type of location (single point, reach, area)	Source of Supply	First National Grid Reference (12 digits)	Second National Grid Reference (12 digits)	Third National Grid Reference (12 digits)	Fourth National Grid Reference (12 digits)
n/a						

If necessary, continue on a separate sheet and tell us the reference for this document.

Document reference(s)

Table 7. 2 Ground water abstractions										
Abstraction location name or reference (as labelled on map)	Source of Supply	National Grid Reference (12 digit)	Overall depth (metres)	Maximum diameter (millimetres) or area of excavation (square metres)	Screened section (metres below ground level)	Drift geology	Solid geology	Rest pump water level	Pumped water level	Pump Depth
Gaens sump	Groundwater	282155 180448	-20 mAOD	Area: 128550 m2	n/a	n/a	Carboniferous Limestone:	c.50mAOD	0mAOD	0mAOD
		282675 180526								
		282739 180187								
		282213 180360								

If necessary, continue on a separate sheet and tell us the reference for this document.

Document reference(s) See report 66664TN1

8. Abstraction history and evidence

8.1 Please complete table 8.1 to document that the abstraction(s) and transfer(s) has or have been taking place during the qualifying period.

If necessary, continue on a separate sheet and tell us the reference for this document.

Document reference(s) See App E of report 66664TN1

Table 8.1

Year	Abstraction location name or reference (as labelled on map)	Purpose(s) water used for	Period of abstraction	Maximum quantities abstracted						Means of measurement, or assessment of abstracted quantities	Are these the maximum quantities of water you wish to have licensed? (Yes or No)
			All year, or months, or days (provide specific dates)	Year (cubic metres)	Day (cubic metres)	Hour (cubic metres)	Peak instantaneous flow rate (litres per second)	Maximum number of hours of abstraction per day	Please indicate whether volume is actual (A) or estimated (E)		
01 January 2011 to 31 December 2011											
01 January 2012 to 31 December 2012											
01 January 2013 to 31 December 2013											
01 January 2014 to 31 December 2014											
01 January 2015 to 31 December 2015											
01 January 2016 to 31 December 2016											
01 January 2017 to 31 December 2017	Quarry sump	Dewatering	All year	628,155	3,928	216	60	24	A and E	Meter less quantity used	Yes

8.2 Please complete the table below if you wish a lesser quantity of water to be licensed than that detailed in table 8.1.

If necessary, continue on a separate sheet and provide a reference for this document.

Document reference: n/a

Table 8.2

Abstraction location name or reference (as labelled on map)	Purpose water is used for	Abstraction period	Maximum annual abstraction volume (cubic metres)	Maximum daily abstraction volume (cubic metres)	Maximum hourly abstraction volume (cubic metres)	Maximum number of hours of abstraction per day	Peak abstraction rate (litres per second)

8.3 Do you wish your abstracted quantities to be aggregated?

You can aggregate:

i) across some or all of the abstraction points, or reaches, or areas listed above.

ii) with other abstractions you wish to have licensed through the transitional process.

iii) abstractions you need to have licensed through the standard licensing process.

iv) with existing licences you hold.

No ☑

Yes ☐ Provide details of any proposed aggregation in the box below. If necessary, continue on a separate sheet and provide a reference for this document.

Document reference:

8.4 Please provide a detailed description of how the abstraction(s) has/have taken place

Use the box below to tell us about your abstraction(s). The description should include the following:

- A diagram or schematic of how the activity has been undertaken, using your abstraction point references and including any discharge points
- Details of the structure and equipment involved in the abstraction. This should include dimensions.
- Details of your means of measurement or assessment of abstraction quantities method

If necessary, continue on a separate sheet and tell us the reference for this document.

Document reference: See report 66664TN1

8.5 Please list the evidence you are providing to support your application

Use the box below. The evidence should demonstrate the following:

- That abstraction has taken place at some time during the seven year qualifying period.
- The quantities of water you have abstracted during the qualifying period. For example, records of meter readings, or cropping plans.

If necessary, continue on a separate sheet and provide a reference for this document.

Document reference: See report 66664TN1

9. Discharge details

9.1 Please provide details on any discharge of abstracted water in table 9.1 below and on the map used to show abstraction locations.

If necessary, continue a separate sheet and provide a reference for this document.

Document reference: See report 66664TN1

Table 9.1 - Details of any discharge of abstracted water

Discharge location name or reference (as labelled on map)	National Grid Reference of discharge point (12 digit)	Total volume discharged (cubic metres)	Environmental Permit number for Water Discharge Activity number (if applicable)
Discharge point	282354 180466	628,155 m3 per year	n/a

9.2 Please provide a description of discharge structures and equipment

See report 66664TN1 discharge to soakaway lagoon on site

If necessary, continue a separate sheet and provide a reference for this document.

Document reference: See report 66664TN1

10. Eel considerations

Does your abstraction include measures to safeguard eels?

No ☑

Yes ☐ Provide details below

n/a

11. Trickle Irrigation

If you are applying to licence a trickle irrigation abstraction, do you wish to apply for a Two-Part Tariff agreement with your application?

No ☑

Yes ☐ We will contact you during determination of your application to arrange this agreement.

12. Planned abstractions

12.1 Do you expect to increase the current rate of abstraction for the activity you are applying to have licensed from 01January 2018 onwards or to carry out further new abstractions (both termed 'planned' abstractions) at this site in the future?

No ☐

Yes ☑

12.2 Have you submitted a licence application (s) for any planned abstraction(s) as a result of the Water Act 2003 changes?

No ☑

Yes ☐ Provide a reference number if you have already submitted an application(s) to cover any planned abstractions.

Document reference

13. Other abstractions

Please provide details of any other abstraction(s) (licensed or exempt) that are associated with this application in table 13.1 below.

Table 13.1 - Details of any other abstraction(s) (licensed or exempt) that are associated with this application

National Grid Reference (12 digit) of where you abstract water	Source name and type	Purpose of abstraction	Where do you use the water?	When do you abstract the water?	Is this a pending application, or already licensed? Please provide the application or licence number as appropriate
as this abstraction	Gaens sump	use	on site	Continiously	pending, accompanies
			see 66664TN1		this application

14. Planning permission

Complete table 14.1 below and provide details of any planning permissions or advice associated with the abstraction you are applying to have licensed where relevant. Provide a copy of any permissions or advice,providing a reference for this document below.

Document reference: Planning permission (ROMP)

Table 14.1 – Planning permission			
Abstraction location name or reference (as labelled on map	Is planning permission needed, Yes or No?	Planning permission status (if required)	Have you received any planning advice for the abstraction?
Gaens Quarry	Yes	Granted (ROMP)	No.

15. Environmental impact assessment(EIA)

Does your application require an EIA under The Water Resources (Environmental Impact Assessment) (England and Wales) Regulations 2003 (as amended)

No ☑

Yes ☐ Please provide a copy of your environmental impact assessment; provide a reference for this assessment below.

Document reference: see Voluntary EIA appnd to 66664TN1

16. Licence duration

Tell us when you wish your abstraction licence to end

Normally abstraction licences are granted for between 6 and 18 years in line with the catchment licence common end date. If you require a shorter or longer duration licence, please provide details and your justification in the box below.

If necessary, continue a separate sheet and provide a reference for this document.

Document reference: See report 66664TN1

Licence should be granted until 6 January 2068

17 Declaration and data protection and commercial confidentiality

Data protection:

Please read the guidance carefully for details on who can sign this section and note the information relating to the Data Protection Act 1998, our Public Register and exclusions.

Commercial confidentiality:

Do you think your application should be confidential, and that information should not be placed on the public register?

No ☑

Yes ☐ You must send us supporting information to tell us why. Use the box below or a separate sheet, and tell us the reference you have given this document.

Document reference

Declaration:

By signing below, you are declaring that as far as you know and believe the information given in this form, on any map and in any supporting or additional information is true.

A printed name in the 'signature' response box will be treated as the equivalent of an electronic signature.

Title	Mr
First name	Samuel
Last name	Rees
Position	Managing Director
Today's date	10/09/2019

Application for a transitional water resources licence

Form WRH

Fill in this form if you are applying for a transitional water resources licence to continue a previously exempt abstraction.

This form is available in both English and Welsh. Please check that this is the latest version of the form available from our website before submitting your application.

Please ensure you use Guidance Note WRH to help you.

All relevant guidance documents can be found on our website.

Contents

1. Application type and fee

1.1 Please select your application type from the list below.

A new transitional water resources full abstraction licence for a previously exempt abstraction ☑

A new transitional water resources transfer licence for a previously exempt abstraction ☐

A variation to an existing full abstraction licence to add a previously exempt abstraction ☐

A variation to an existing transfer licence to add a previously exempt abstraction ☐

1.2 Please indicate the amount and how you wish to pay your application

Amount paid: 135

Cheque ☑

Credit or debit card ☐

BACS transfer ☐ BACS reference number: PRC

2 Applicant and agent details

This is the individual or organisation any resulting licence will be issued to, and must be a legal entity. If you are an agent acting on behalf of an applicant, provide their details here and yours in section 2.2.

2.1 Applicant details

Individual ☐ Public body ☐

Registered company ☑ Organisation or group of individuals ☐

Other ☐ If 'Other', please specify

Title: Mr

First name	Sam
Last name	Rees
Company, charity, body, or trading name (if relevant)	
Registered company or charity number (if relevant)	TS Rees Limited
Address	Cornelly Quarries
	Pyle
	Glam
Postcode	CF33 4RD
Telephone - mobile	
Telephone - office	
Email address	tsreesltd@btconnect.com

We will contact you by email unless you tick here. ☐

2.2 Agent details

This is who we will correspond with unless otherwise informed. If you are an agent applying on behalf of an applicant, please include a letter of authorisation from the applicant allowing you to act as signatory,and provide a reference for this document in the box below.

Document reference		
Title	Ms	
First name	Kate	
Last name	Brady	
Company or trading name	Stantec UK Ltd	
Position in company	Senior Consultant	
Address	New Zealand House	
	160 Abbey Foregate	

Shrewsbury

Shropshire

Postcode SY2 6FD

Telephone - mobile 07376 497250

Telephone - office 01743 276117

Email address kate.brady@stantec.com

We will contact you by email unless you tick here. ☐

2.3 Site operation contact

Please specify who we should contact with regard to your site operation.

Applicant ☐

Agent ☑

Other ☐ Please provide contact details for the operational contact on a separate referenced document, and tell us this reference below.

Document reference

2.4 Abstraction invoices and records contact

Please specify who we should contact for invoices and abstraction records (returns). Please note that these may not be not required for transfer licences.

Invoice address

Applicant ☑

Agent ☐

Other ☐ Please provide contact details for the operational contact on a separate referenced document, and tell us this reference below.

Document reference

Abstraction records

Applicant ☑

Agent ☐

Other ☐ Please provide contact details for the operational contact on a separate referenced document, and tell us this reference below.

Document reference

3. Site name

3.1 Please provide the site name below:

Site name Gaens Quarry

4. Entitlement to apply

4.1 Have you abstracted water between 01 January 2011 and 31 December 2017 for the activity which you are applying to be licensed?

Yes ☑

No ☐ Please see our water abstraction and impounding webpage for further information on the correct applicaton forms.

4.2 What is your connection to the land where the abstraction takes place?

Please provide a map outlining your land ownership/occupation and include all abstractions and discharges where relevant.

Owner ☑

Occupier ☐

Document reference: Red line in Fig 1.1 of report 66664TN1

4.3 Do you have a legal right of access to the land where the abstraction take place?

No ☐

Yes ☑ Please provide further detail in the box below. If necessary continue on a separate referenced document, and tell us this reference.

Document reference: ROMP permission

See Appendix B of report 66664TN1

5. Existing licence number(s)

If you are applying to change an existing licence please provide the licence number below.

Licence number(s): n/a

6. Cross border applications

As part of your site operation do you also abstract for a previously exempt activity in England?

No ☑

Yes ☐ Please provide detail of this cross border application in the box below. If possible, provide a reference or application number, or name of an Environment Agency contact with whom the application has been discussed.

Continue on a separate referenced sheet if necessary and tell us the reference for this document.

Document reference:

7. Abstraction details

7.1 Site map

Please provide a map with details of the location(s) you abstract water from (points reaches, or areas). Tell us the reference for this map, below.

Site map reference: See report 66664TN1, Figure 2.2

7.2 Please tell us details about the location(s) you abstract water from (points reaches, or areas) in the tables below.

The abstraction location, name, or reference must be the same as those used on the site map, in question 7.1. If you need more space, please continue on a separate referenced sheet if necessary and tell us the reference for this document

Document reference: ROMP Area in Figure 2.2 in 66664TN1

Table 7. 1 - Surface water abstractions						
Abstraction location name or reference (As labelled on the site map)	Type of location (single point, reach, area)	Source of Supply	First National Grid Reference (12 digits)	Second National Grid Reference (12 digits)	Third National Grid Reference (12 digits)	Fourth National Grid Reference (12 digits)
n/a						

If necessary, continue on a separate sheet and tell us the reference for this document.

Document reference(s)

Table 7. 2 Ground water abstractions										
Abstraction location name or reference (as labelled on map)	Source of Supply	National Grid Reference (12 digit)	Overall depth (metres)	Maximum diameter (millimetres) or area of excavation (square metres)	Screened section (metres below ground level)	Drift geology	Solid geology	Rest pump water level	Pumped water level	Pump Depth
Gaens sump	Groundwater	282155 180448	-20 mAOD	Area: 128550 m2	n/a	n/a	Carboniferous Limestone:	c.50mAOD	0mAOD	0mAOD
		282675 180526								
		282739 180187								
		282213 180360								

If necessary, continue on a separate sheet and tell us the reference for this document.

Document reference(s) See report 66664TN1

8. Abstraction history and evidence

8.1 Please complete table 8.1 to document that the abstraction(s) and transfer(s) has or have been taking place during the qualifying period.

If necessary, continue on a separate sheet and tell us the reference for this document.

Document reference(s) See App E of report 66664TN1

Table 8.1

Year	Abstraction location name or reference (as labelled on map)	Purpose(s) water used for	Period of abstraction	Maximum quantities abstracted						Means of measurement, or assessment of abstracted quantities	Are these the maximum quantities of water you wish to have licensed? (Yes or No)
			All year, or months, or days (provide specific dates)	Year (cubic metres)	Day (cubic metres)	Hour (cubic metres)	Peak instantaneous flow rate (litres per second)	Maximum number of hours of abstraction per day	Please indicate whether volume is actual (A) or estimated (E)		
01 January 2011 to 31 December 2011											
01 January 2012 to 31 December 2012											
01 January 2013 to 31 December 2013											
01 January 2014 to 31 December 2014											
01 January 2015 to 31 December 2015											
01 January 2016 to 31 December 2016											
01 January 2017 to 31 December 2017	Quarry sump	Dewatering	All year	28,545	172	172	60	24	E	Site staff testimony	Yes

8.2 Please complete the table below if you wish a lesser quantity of water to be licensed than that detailed in table 8.1.

If necessary, continue on a separate sheet and provide a reference for this document.

Document reference: n/a

Table 8.2

Abstraction location name or reference (as labelled on map)	Purpose water is used for	Abstraction period	Maximum annual abstraction volume (cubic metres)	Maximum daily abstraction volume (cubic metres)	Maximum hourly abstraction volume (cubic metres)	Maximum number of hours of abstraction per day	Peak abstraction rate (litres per second)

8.3 Do you wish your abstracted quantities to be aggregated?

You can aggregate:

i) across some or all of the abstraction points, or reaches, or areas listed above.

ii) with other abstractions you wish to have licensed through the transitional process.

iii) abstractions you need to have licensed through the standard licensing process.

iv) with existing licences you hold.

No ☑

Yes ☐ Provide details of any proposed aggregation in the box below. If necessary, continue on a separate sheet and provide a reference for this document.

Document reference:

8.4 Please provide a detailed description of how the abstraction(s) has/have taken place

Use the box below to tell us about your abstraction(s). The description should include the following:

- A diagram or schematic of how the activity has been undertaken, using your abstraction point references and including any discharge points
- Details of the structure and equipment involved in the abstraction. This should include dimensions.
- Details of your means of measurement or assessment of abstraction quantities method

If necessary, continue on a separate sheet and tell us the reference for this document.

Document reference: See report 66664TN1

8.5 Please list the evidence you are providing to support your application

Use the box below. The evidence should demonstrate the following:

- That abstraction has taken place at some time during the seven year qualifying period.
- The quantities of water you have abstracted during the qualifying period. For example, records of meter readings, or cropping plans.

If necessary, continue on a separate sheet and provide a reference for this document.

Document reference: See report 66664TN1

9. Discharge details

9.1 Please provide details on any discharge of abstracted water in table 9.1 below and on the map used to show abstraction locations.

If necessary, continue a separate sheet and provide a reference for this document.

Document reference: See associated transfer forms

Table 9.1 - Details of any discharge of abstracted water

Discharge location name or reference (as labelled on map)	National Grid Reference of discharge point (12 digit)	Total volume discharged (cubic metres)	Environmental Permit number for Water Discharge Activity number (if applicable)

9.2 Please provide a description of discharge structures and equipment

If necessary, continue a separate sheet and provide a reference for this document.

Document reference

10. Eel considerations

Does your abstraction include measures to safeguard eels?

No ☑

Yes ☐ Provide details below

n/a

11. Trickle Irrigation

If you are applying to licence a trickle irrigation abstraction, do you wish to apply for a Two-Part Tariff agreement with your application?

No ☑

Yes ☐ We will contact you during determination of your application to arrange this agreement.

12. Planned abstractions

12.1 Do you expect to increase the current rate of abstraction for the activity you are applying to have licensed from 01January 2018 onwards or to carry out further new abstractions (both termed 'planned' abstractions) at this site in the future?

No ☐

Yes ☑

12.2 Have you submitted a licence application (s) for any planned abstraction(s) as a result of the Water Act 2003 changes?

No ☑

Yes ☐ Provide a reference number if you have already submitted an application(s) to cover any planned abstractions.

Document reference

13. Other abstractions

Please provide details of any other abstraction(s) (licensed or exempt) that are associated with this application in table 13.1 below.

Table 13.1 - Details of any other abstraction(s) (licensed or exempt) that are associated with this application

National Grid Reference (12 digit) of where you abstract water	Source name and type	Purpose of abstraction	Where do you use the water?	When do you abstract the water?	Is this a pending application, or already licensed? Please provide the application or licence number as appropriate
as this abstraction	Gaens sump	transfer	transfer only	Continuously	pending, accompanies
			see 66664TN1		this application

14. Planning permission

Complete table 14.1 below and provide details of any planning permissions or advice associated with the abstraction you are applying to have licensed where relevant. Provide a copy of any permissions or advice,providing a reference for this document below.

Document reference: Planning permission (ROMP)

Table 14.1 – Planning permission

Abstraction location name or reference (as labelled on map	Is planning permission needed, Yes or No?	Planning permission status (if required)	Have you received any planning advice for the abstraction?
Gaens Quarry	Yes	Granted (ROMP)	No

15. Environmental impact assessment(EIA)

Does your application require an EIA under The Water Resources (Environmental Impact Assessment) (England and Wales) Regulations 2003 (as amended)

No ☑

Yes ☐ Please provide a copy of your environmental impact assessment; provide a reference for this assessment below.

Document reference: see Voluntary EIA appnd to 66664TN1

16. Licence duration

Tell us when you wish your abstraction licence to end

Normally abstraction licences are granted for between 6 and 18 years in line with the catchment licence common end date. If you require a shorter or longer duration licence, please provide details and your justification in the box below.

If necessary, continue a separate sheet and provide a reference for this document.

Document reference: See report 66664TN1

Licence should be granted until 6 January 2068

17 Declaration and data protection and commercial confidentiality

Data protection:

Please read the guidance carefully for details on who can sign this section and note the information relating to the Data Protection Act 1998, our Public Register and exclusions.

Commercial confidentiality:

Do you think your application should be confidential, and that information should not be placed on the public register?

No ☑

Yes	☐	You must send us supporting information to tell us why. Use the box below or a separate sheet, and tell us the reference you have given this document.

Document reference

Declaration:

By signing below, you are declaring that as far as you know and believe the information given in this form, on any map and in any supporting or additional information is true.

A printed name in the 'signature' response box will be treated as the equivalent of an electronic signature.

Title	Mr
First name	Samuel
Last name	Rees
Position	Managing Director
Today's date	10/09/2019

Appendix B

ROMP permission

Lesley Griffiths AC/AM
Ysgrifennydd y Cabinet dros yr Amgylchedd a Materion Gwledig
Cabinet Secretary for Environment and Rural Affairs

Llywodraeth Cymru
Welsh Government

Ein cyf/Our ref A-PAA-25-08-004

Mr Will Ryan
Director – Planning
Savills
12 Windsor Place
Cardiff
CF10 3BY

22 December 2016

REVIEW OF OLD MINERAL PERMISSIONS (ROMP)

APPLICATION C CONSISTING OF THE SUBMISSION OF REVISED PLANNING CONDITIONS FOR APPROVAL FOR GAENS QUARRY, NEAR SOUTH CORNELLY, BRIDGEND

APPLICATION B IS ONE OF FOUR RELATED APPLICATIONS MADE UNDER THE PLANNING AND COMPENSATION ACT 1991 AND THE ENVIRONMENT ACT 1995, SCHEDULES 13 AND 14

1. Consideration has been given to the report of the appointed Inspector Clive Nield BSc, CEng, MICE, MCIWEM, who held a local inquiry into the four applications for the approval of revised planning conditions under the above legislation. The four applications (applications A-D) were to be considered together because the cases are inextricably linked in terms of working method, environmental impact, water management, monitoring and mitigation, final restoration and after use.

2. The Secretary of State for Wales called in the three ROMP applications for Gaens, Grove and Cornelly quarries under paragraph 13 of Schedule 13 to the 1995 Act and the IDO application for Cornelly and Grove quarry under paragraph 8 of Schedule 14

to that Act. The functions of the Secretary of State in all relevant respects now vest in the Welsh Ministers. The first application to be called in was at Gaens quarry on the 14th May, 1998. The two other ROMP applications for Grove and Cornelly quarries were called in on the 9th July, 1998. The IDO application submitted for Cornelly and Grove quarries was called in on the 11th February, 2010.

3. The ROMP application submitted for Cornelly (Application A) quarry was made by Cambrian Stone (a Tarmac joint venture company). The ROMP application submitted for Grove quarry (Application B) was made by Pioneer Aggregates Ltd. Although the Grove quarry application was originally submitted in the name of Pioneer Aggregates Ltd, the ownership of the quarry changed to the Tarmac Group (Lafarge Tarmac Ltd). At the outset of the public inquiry it was confirmed ownership now lay with Tarmac Trading Ltd. The ROMP application (Application C) submitted in relation to Gaens quarry was made by T.S.Rees Ltd. The IDO application submitted for Cornelly and Grove quarries (Application D) was made by Cambrian Stone Ltd in respect of Grove quarry and Tarmac (South Western) Ltd in respect of Cornelly quarry.

4. The three ROMP applications were not subject to formal environmental impact assessment (EIA) when they were originally submitted but EIA was undertaken voluntarily and Environmental Statements submitted. The IDO application for Cornelly and Grove quarries which, having been submitted much later, fell within the scope of the Town and Country Planning (Environmental Impact Assessment) (England and Wales) regulations 1999 as amended. In 2009, the Town and Country (Environmental Impact Assessment) (Undetermined Reviews of Old Mineral permissions) (Wales) Regulations 2009 formally made EIA a mandatory requirement for the three ROMP applications.

5. Since the three ROMP applications and the voluntary Environmental Statements were submitted, the information contained in Environmental Statements has been substantially updated for each quarry. The latest Environmental Statement for each application contained a new proposed schedule of conditions and updated Water Management Plan. These Environmental Statements were published for consultation on the 26th June 2014 and the public given full opportunity to inspect information. Natural Resources Wales (NRW) has been consulted regularly by all parties and played an important role in seeking to analyse and resolve all matters relating to the water environment, particularly potential effects on the Kenfig/Cynffig Special Area of Conservation (SAC). It also participated fully in the inquiry process.

6. The Inspector's report is published alongside this letter. A note of correction applies to paragraph 135, where reference to "12mm" should be "12cm".

Planning Considerations

7. With regard to the consideration of the proposals against relevant national and local policy it is important to note the principle of mineral extraction at these quarries is

already established by the extant planning permissions. Only the submitted conditions are the subject of determination for approval. Nonetheless, policy and guidance in the form of Planning Policy Wales, Minerals Technical Advice Note 1, Mineral Planning Policy Guidance 14 and the Bridgend Local Development Plan (adopted September 2013) has been taken into account in processing the applications.

8. The Inspector's overall conclusions are set out at paragraph's 158-159 of his report which is attached at Annex 3 to this letter. The Inspector recommended that the applications comprising the four sets of conditions be approved. A copy of the conditions is appended to the report of the Inspector at Annex A-D.

9. All four applications will be the subject in the future of further Periodic Reviews every 15 years in accordance with the Environment Act 1995.

10. In the Inspector's view the main issues are the impacts of quarry deepening on the hydrogeological regime between the quarries and the Kenfig/Cynffig SAC located some 2 km to the west. For Gaens quarry, an additional consideration is whether or not future blasting in close proximity to residential properties can be adequately controlled.

11. The Inspector's overall conclusions are there is a level of agreement between the relevant parties to a point where conditions can be applied to address hydrogeological, ecological and amenity matters to an acceptable degree.

Hydrogeological and ecological matters

12. The Inspector recommended at paragraph 153 of his report that the shadow appropriate assessment contained in the Environmental Statements for each application made inadequate provision for the possibility of encountering certain features which could lead to high rates of water flow in the aquifer and the risk, however small, needed a more thorough assessment so that the planning conditions and other measures such as the Water Management Plan would not lead to an adverse effect on the integrity of the Kenfig/Cynffig SAC. He therefore recommended that Welsh Ministers carry out appropriate assessment.

13. An appropriate assessment has been carried out and is contained at annex 2 of this letter and it represents my assessment of hydrogeological and ecological matters with regard to the relevant European protected site. Its considerations are not repeated here, other than to say, on the basis of it being undertaken and the imposition of conditions requiring the adoption of the latest Water Management Plan for each of the quarries, I conclude that there would not be an adverse effect on the integrity of the Kenfig/Cynffig SAC as a result of the proposed future quarrying operations.

Other matters

14. Other matters to be considered are on-site ecological ones relating to biodiversity enhancements, landscape and visual impact, noise limits, blasting levels, dust controls, highway impacts and the progressive and long term restoration of the sites. I consider the proposals have been given significant and robust analysis against both national and local policy and guidance in relation to all relevant issues and I agree with the Inspector's conclusions that the conditions proposed are capable of effectively controlling these matters.

15. The report of the Inspector at paragraphs 58-62 deals with the matters relating to those conditions which have been agreed by Bridgend Country Borough Council, Tarmac and T.S. Rees Ltd. Several other matters raised by third parties, detailed in paragraphs 115-125 of the Inspector's report, have been considered and conditions, as summarised in paragraphs 126-132 of the Inspector's report, are capable of satisfying those concerns.

16. Of the three quarries, Gaens quarry is located closest to the highest concentration of residential properties in South Cornelly. Dust and blasting vibration levels and a small private water supply have all been the subject of detailed scrutiny and I agree with the Inspector's conclusion of appropriate revised conditions being able to mitigate any adverse effects to an acceptable degree.

17. The conditions set out in the report of the Inspector as at Annexes A-D (pages 39-78) of the Inspectors report have been the subject of open discussion at the public inquiry. I have considered these conditions and subject to the comments and amendments listed below in paragraphs 18-33 I agree they should be approved.

<u>Conditions relating to the duration of the permissions</u>

18. Welsh Ministers have considered the proposed expiry dates of the permissions taking into account Schedule 2.2(1)c of the Planning and Compensation Act 1991 which states inter alia " *the conditions to which an old mining permission is to be the subject must include a condition that the winning and working of minerals or depositing of mineral waste must cease not later than 21st February,2042".*

19. The current conditions seek consent for expiry dates beyond this date and therefore it has been necessary to determine if expiry dates running to a maximum of 2056 (for applications A, B and D) and 2068 (for application C) are acceptable. The overall development programme for each quarry has been informed by environmental impact assessment and the Environmental Statements set out the projected life of each site based on current production figures and the consented reserves.

20. Firstly, the quarries are strategic ones, providing both aggregate and high purity limestone for the steel industry. Levels of sales and output have been considered over the timescales proposed and although these could be subject to change we do not have any evidence to doubt the longevity of the quarries at this time.

21. Secondly, the prolonged period over which data and environmental information has been collected has resulted in a sophisticated modelling and monitoring framework being in place to control operations at the quarries which includes extensive mitigation and contingency measures. Natural Resources Wales have been involved in the design and approval of these measures and the appropriate assessment shows that there would not be an adverse effect on the integrity of the SAC.

22. Thirdly, the environmental impact assessment and resulting conditions allow for sufficient and appropriate control of impacts of concern to local residents.

23. Having examined these factors the wider socio- economic benefits of extending the life of the quarries along with the ability to acceptably control any significant environmental impacts means the balance falls in allowing expiry dates to be extended beyond 2042 on a quarry by quarry basis. For these reasons I consider it appropriate to extend the expiry dates of these permissions.

<u>Other conditions</u>

24. In Condition 8, it is noted the working hours as set out in 8 (a) extend into early morning and late evening periods. Such working may generate some inconvenience to local residents by way of noise and movement of traffic entering and leaving the site. The site entrance is located in a residential area and therefore sensitive to excessive noise. Yet there are no conditions restricting working hours attached to applications A, B and D.

25. The proposed 06-00 -2200 hours (Mon - Friday) and 06.00 -16.00 hours (Sat) for normal quarry operations is inconsistent with the guide to conditions set out in Annex M of Minerals Planning Guidance 14 Review of Mineral Planning Permissions (MPG 14). Whilst the conditions in MPG 14 are illustrative only, they do form the basis for considering any new conditions and constitute good practice.

26. The Inspector in his report makes no reference to the difference between the proposed conditions and those set out in MPG14, other than in paragraph 127, where there is reference to the fact that some of the conditions have been subject to some limited compromise to take into account the current largely unfettered controls applied to the quarry.

27. If restricted working hours were imposed, other than those submitted for approval, it is possible a claim for compensation could be made based on the potential effect on the asset value/economic viability of the quarry. Such a claim would be determined on its merits taking into account the significance of the change and the impact on the operation of the site.

28. I have felt it necessary to consider whether some restriction in working hours over and above those proposed in the schedule of conditions is appropriate. In doing so, due regard has been given to all of the factors set out in the Inspector's report at paragraphs 116-125 and 129. Taking into consideration the circumstances at the site

and current planning policy and guidance, together with the lack of substantive concerns raised by the general public or Bridgend County Borough Council, it is considered the hours specified are acceptable.

29. Reference is made in Conditions 9 and 10 to the Water Management Plan which shall be carried out throughout the life of the development. As stated in the report of the Inspector at paragraph 146, the Water Management Plan will need to be implemented beyond the cessation of quarrying operations on the site. Hence, for greater clarity the condition should be revised so that the Water Management Plan is directly linked to the duration of the planning permission and the 5 year aftercare period.

30. Condition 9 should be amended to read:-

"The water management, monitoring, reporting, mitigation and contingency activities set out in the Water Management Plan (WMP) for Gaens Quarry v5.8 dated 9th November 2015 shall be carried out throughout the duration of the planning permission and the 5 year aftercare period."

31. Condition 10 should be amended to read:-

"In the event that the Minerals Planning Authority requires changes to the WMP, as provided for in the WMP, then the amended water management, monitoring, reporting, mitigation and contingency activities requested by the Minerals Planning Authority shall be carried for the duration of the planning permission and the 5 year aftercare period."

32. For the purposes of consistency with applications A, B and D and in the interests of public safety and livestock control, condition 17 should be replaced with the following condition:-.

"A minimum 1.3 metre stockproof and two strand barbed wire fence should be maintained around the entire site perimeter (with the exception of lockable gates where necessary), together with quarry warning signs at 25 metre intervals".

Additional conditions considered necessary

33. For the purposes of consistency with applications A, B and D, the following two bullet points should be added to condition 32:-

"Site roads within the quarry shall be dampened down as appropriate, in accordance with the requirement of conditions 31 and 32.

The site entrance road shall be maintained by use of a road sweeper which shall operate as required to maintain the surface of the road free of mud and other detritus."

Formal Decision

34. Subject to the appropriate assessment at annex 1 and the suggested amendments and additions contained in this letter I agree with the Inspector's conclusions and accept his recommendation.

35. For clarity the full set of conditions, as amended, is attached at annex 2. Accordingly, I hereby approve the conditions contained at annex 2 of this letter.

36. This letter, a copy of which has been sent to Bridgend County Borough Council and to those interested persons who appeared at the inquiry, does not convey any approval or consent which may be required under any enactment, bye law, order or regulation other than the application made under paragraph 9 of Schedule 13 of the Environment Act 1995.

Yours sincerely

Lesley Griffiths

Lesley Griffiths AC/AM
Ysgrifennydd y Cabinet dros yr Amgylchedd a Materion Gwledig
Cabinet Secretary for Environment and Rural Affairs

FINAL APPROPRIATE ASSESSMENT UNDER REGULATION 61 (6) THE CONSERVATION OF HABITATS AND SPECIES REGULATIONS 2010, AS AMENDED

1 Introduction

1.1 This Appendix constitutes the Appropriate Assessment carried out by Welsh Ministers under paragraph 61(6) of The Conservation of Habitats and Species Regulations (Habitats Regulations) 2010, as amended, relating to the Review of Old Mineral Planning Permissions (ROMPs) Cornelly, Grove and Gaens quarries and the Periodic Review of Interim Development Order (IDO) Cornelly and Grove quarries, South Cornelly, Bridgend.

1.2 Matters pertaining to the Habitats Regulations were considered by the Inspector at the Public Local Inquiry in November 2015 and summarised in his report at paragraphs 147-154. These matters are noted, including the recommendation that Welsh Ministers undertake an Appropriate Assessment as part of its determination of the applications to satisfy themselves that the applications will not result in adverse effects on the integrity of the Kenfig/Cynffig Special Area of Conservation (SAC).

1.3 This assessment has been undertaken in accord with the guidance contained in TAN 5 Nature Conservation and Planning. TAN 5 states "*If the decision-taker concludes that a proposed development not directly connected with site management is likely to significantly affect a European site or European offshore marine site, they must make an appropriate assessment of the implications of the proposal for the site in view of the site's conservation objectives*".

1.4 In accordance with regulation 61(3) of the Habitats Regulations Welsh Ministers, as the competent authority, must consult with the statutory nature conservation body, in this case Natural Resources Wales (NRW), as part of the Appropriate Assessment. Consultation responses received from NRW in the letter dated 5 July have been incorporated into this assessment.

1.5 Consultation with other parties, including the public, can be undertaken but is not required by the regulations. The publicity and consultation in respect of the Environment Statements and the examination of the cases at the Public Local Inquiry suggest that sufficient opportunity for wider engagement on these applications has been provided and no further consultation has been undertaken.

2 Background

2.1 Determining whether a project is likely to have a significant effect on a European site, either alone or in combination with other plans or projects, can be made at any time during the decision making process. Welsh Ministers recognise the unique circumstances pertaining to these cases and that the collection and submission of relevant information has taken place in an iterative way over a number of years.

2.2 The tacit implication of attaching a shadow appropriate assessment template to the relevant Scoping Decisions, made under the Town and Country Planning (Environmental Impact Assessment) (Undetermined Review of Old Minerals Permissions) (Wales) Regulations 2009 on 4 March 2013, was that it was not possible to exclude the potential of a likely significant effect occurring, on the basis of objective information available at the time.

2.3 Notwithstanding the on-going refinement of the hydrogeological modelling, the collection of monitoring data and the iterative submission of information associated with these proposals, Welsh Ministers consider it necessary to undertake an Appropriate Assessment, under the Habitats Regulations, to satisfy itself that the proposals would not adversely affect the integrity of the Kenfig/Cynfigg SAC.

2.4 The Scoping Directions directly requested that the potential impact of quarrying on Kenfig/Cynffig SAC/SSSIs and Cefn Cribwr Grasslands SAC/SSSIs be included in the Environment Statements for all four applications. More remote SACs such as Blackmill Woodlands were discounted on the basis of no likely significant effect. Other designated sites, both statutory, such as SSSIs, and non-statutory have been considered as part of the environmental impact assessment of the quarry proposals.

2.5 The Cefn Cribwr Grasslands SAC comprises four separate areas of grassland to the north of the group of quarries. It is one of four sites representing ***Molinia* meadows** in south and central Wales, one of the major UK strongholds for this habitat type and this, along with the Marsh fritillary butterfly, represents the qualifying features of the SAC. Whilst the qualifying features of the SAC are dependent on groundwater features they are not dependent on groundwater features that could be affected by dewatering of the Cornelly group of quarries. There is no mechanism by which the quarry proposals could have a significant effect on the SAC, and there is no need to make any further appropriate assessment under the Habitats Regulations in relation to this European site.

2.6 The position for the Kenfig/Cynffig SAC, however, is that the maintenance of the natural hydrological regime of both of its dune systems is critical for the maintenance of the character, composition and condition of the features. For this reason the Kenfig/Cynffig SAC is being taken forward for inclusion in the Appropriate Assessment.

3 Kenfig/Cynffig SAC

3.1 The SAC comprises two discreet areas – the dune fields of Kenfig, including pool and the dunes at Merthyr Mawr.

Designated: December 2004
Area: 1,191.67Ha

3.2 Kenfig is a largely intact dune system with extensive areas of fixed dune vegetation with red fescue *Festuca rubra* and lady's bedstraw *Galium verum* and semi-fixed dune grassland with marram *Ammophila arenaria* and red fescue. There is also a relatively large area of more acidic vegetation dominated by sand sedge Carex *arenaria*, sheep's-fescue *Festuca ovina* and common bent *Agrostis capillaris*.

3.3 It contains one of the largest series of dune slacks in Wales which are species-rich and there are extensive areas of dunes with *Salix repens* ssp. *argentea*, which represent a mature phase in dune slack development. The site is in the central part of the range of this community on the west coast and is a highly representative example of this habitat type.

3.4 Kenfig also contains the most important example of Humid dune slacks in the UK, owing to the extent of the habitat type and the conservation of its structure and function. These calcareous dune slacks are also amongst the most species-rich in the UK, supporting communities dominated by a variety of mosses and a number of rare plants, notably Fen orchid *Liparis loeselii*, for which the site is also selected. Some of the dune slacks on the site are still in the early successional stage of development.

3.5 Kenfig Pool is a shallow lake within the extensive sand dune system of Kenfig, the water chemistry is indicative of a coastal, alkaline lake with a moderate nutrient status with the presence of Chara spp.

3.6 Reasons for Recommendation of SAC:

Humid dune slacks (EU Habitat Code: 2190)
Dunes with *Salix repens* ssp. *argentea* (*Salicion arenariae*) (EU Habitat Code: 2170)
Fixed dunes with herbaceous vegetation ("grey dunes") (EU Habitat Code: 2130)
Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp. (EU Habitat Code: 3140)
Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) (EU Habitat Code: 1330)
Petalwort *Petalophyllum ralfsii* (EU Species Code: 1395)
Fen orchid *Liparis loeselii* (EU Species Code: 1903)

3.7 The Conservation Objectives for the Kenfig/Cynffig SAC are set out in the Core Management Plan:

Kenfig/Cynffig SAC (CCW 9th April 2008, map edit February 2013) available at:
https://www.naturalresources.wales/media/672610/Kenfig%20SAC%20management%20plan%2021.4.08%20English.pdf

The management plan describes site condition and Favourable Conservation status. A useful summary is contained within the Applicants' Shadow

Appropriate Assessment (refer to Cornelly Environmental Statement Vol 2D, Appendix 8.3).

4 Brief description of the project

4.1 The Cornelly group of quarries are situated on land south of junction 37 on the M4 between Bridgend and Pyle. They are sited in a ridge of Carboniferous Limestone, on the southern edge of the South Wales syncline, with a ground surface level up to 100m. The land falls steeply to the west and south west, to low rolling ground sloping gently to the sea. The end date for the quarries is 2042.

4.2 Gaens quarry
The area covered by consents for mineral extraction is approximately 13 ha. The most recent known proposals are for a phased extraction scheme to deepen the quarry from approximately 30m AOD to -20m AOD.

4.3 Cornelly quarry
The area covered by consents for mineral extraction is approximately 76 ha. The most recent known proposals are to develop the quarry from approximately 6m AOD (2007) to -75m AOD. Output is about 1 million tonnes per annum. The quarry will be dewatered by pumping to Pant Mawr and/or Grove quarries, or Stormy Down quarry. Pumping to Pant Mawr and/or Grove quarries averaged 1680m^3/day, 2001-06. The western area is covered by an IDO permission subject to the first periodic review, the east is subject to a ROMP review, and newer permissions also overlap the IDO. When dewatering of the quarry ceases, the groundwater is predicted to recover to, variously, 40-45m AOD or approximately 56m AOD, and restoration works would be confined to the levels above 50m AOD.

4.4 Grove quarry
The area covered by consents for mineral extraction is approximately 30 ha. The eastern area is covered by an IDO permission subject to the first periodic review, the west is subject to a ROMP review. The most recent known proposals are to work the quarry to 15m AOD in the IDO area and to -15m AOD in the ROMP area. (0m AOD in the IDO Environmental Statement). It is considered that output would be in the region of 250,000 tonnes per annum. The ROMP area void would be partly filled with overburden from the IDO area (1 million cubic metres). A final water level of approximately 25m AOD is anticipated.

5 Identifying the potential effects on the Kenfig/Cynffig SAC

5.1 It is necessary to identify all possible sources of effects from the project under consideration, or and any other effects likely to arise from other proposed projects or plans, together with all other sources in the existing environment which might act in combination.

5.2 The types of impacts likely to affect aspects of the structure and function of the SAC which are vulnerable to change are considered to be related to water supply and quality. The potential for effect is dependent on pathways between the source (the Cornelly quarries) and the receptors (the SAC). This is influenced both by the geology (particularly the possibility of karst features in the carboniferous limestone), the surface water regime and groundwater levels and flow directions.

5.3 The key SAC features for consideration are the dune slacks and their associated communities (including the dunes with creeping willow) and the fen orchid and petalwort species features which are dependent on water levels for their integrity and Kenfig pool, which could be reduced in size should groundwater levels change reducing the available habitat for chara species.

5.4 The key areas of concern have related to:-

- Outflows from the aquifer
- Conditions at depth in the quarries
- Connection between the limestone aquifer and the dune system at both Kenfig and Merthyr Mawr
- Migration of leachate from the landfills
- Saline intrusion into the aquifer
- Impacts of quarry dewatering and water disposal
- Impacts of quarry recharge

5.5 In worst-case scenarios, it was considered that:-

- draw-down in the groundwater table beneath the SAC would result in a loss of habitat area and lead to a significant and permanent deterioration in habitat condition/loss of species;
- draw-down in the groundwater table could last for the life of the permission and period of water rebound, with some permanent effects as a consequence of the void;
- Changes to the water quality from saline intrusion or alterations to pollution plumes would affect the SACs.

5.6 It is agreed between all parties that the planned quarrying operations are not predicted to have any material impact on water quality in the surrounding areas nor are the operations predicted to cause saline intrusion into the aquifer. Thus, migration of leachate from Stormy West and Tythegston landfill sites, saline intrusion and worst case scenarios associated with such impacts are not considered any further as part of this appropriate assessment.

5.7 The detailed positions for Kenfig dunes and pool and Merthyr Maw dunes are discussed in section 4.2 of the Shadow Appropriate Assessment and Chapter 7 of the Cornelly Environment Statement (Chapter 7; and, Vol 2D Appendix 8.3). Issues of common ground between both sets of applicants and Natural Resources Wales were submitted to the Public Local Inquiry in November 2015.

6 Factors for further detailed assessment

6.1 The process of determining these applications has been the subject of prolonged and detailed scrutiny and it is not considered appropriate to reproduce this at length as part of this assessment. Reference should be made to section 7.2.6 of the Cornelly Environmental Statement and paragraphs 27-28 and pages 36-38 of the Inspectors report which summarises the iterative process and details the most up to date pieces of information and evidence submitted as part of the Inquiry. It is suffice to say that widespread studies and investigations have been carried out in response to hydrogeological concerns and potential impacts on the Kenfig/Cynffig SAC. These have provided data to enable the aquifer to be modelled and forecast data to be derived based on simulation of the proposed future operations.

6.2 The four applications were called in for determination by the Welsh Office and Welsh Ministers in 1998 and 2010 respectively and those called in by the Welsh Office were subsequently transferred to the National Assembly for Wales and to Welsh Ministers. The applications were called in because of potential significant effects on the water environment, with the hydrological information sought still outstanding. The four cases overlap in terms of the area covered and issues raised and it was recommended that all four be considered together by means of a joint Public Inquiry, with a single Inspector considering all planning issues arising, including an integrated approach towards a strategic restoration scheme. For the purposes of the Appropriate Assessment because all quarries could be worked together the assessment was conducted based on the in-combination effects of working at all three quarries.

6.3 Statements of common ground were prepared to inform the Public Local Inquiry. No further assessment of these issues is proposed as part of the Appropriate Assessment.

6.4 The main outstanding issues considered at the Inquiry are summarised by the Inspector at paragraph 133 of his report as:

- confidence in the hydrogeological modelling;
- the impact of further dewatering of the quarries on the Kenfig/Cynffig SAC; and,
- the degree of reliance on the Water Management Plan for the life of the quarries.

6.5 Implicit in these considerations is the determination of an appropriate threshold (level of change) and trigger (an early warning system) for both assessing and being able to avoid an adverse impact in the Kenfig/Cynffig SAC, the effectiveness/robustness of the Water Management Plans to monitor and mitigate any hydrological impacts on the SAC as a result of quarrying and whether or not any risk (albeit small) of rapid groundwater movement as a result of an interception with a karstic feature could be addressed by way of planning condition. These issues will be considered below.

6.6 Level of confidence in the hydrogeological modelling

6.6.1 The conceptual and groundwater models provide a reliable representation of the ground water system around the quarries. The modelling was undertaken to:

- enhance understanding of the degree of potential connectivity between the underlying aquifer and both Kenfig and Merthyr Mawr dune systems and the possible impacts on the designated features of the SAC if the connection between the sites is greater than anticipated,
- to identify the main outflows from the aquifer; and,
- to put in place effective water management options at the quarry.

6.6.2 The hydrogeological model has been used to simulate the future groundwater drawdown circumstances that are likely to occur if and when the quarries (particularly Cornelly) are worked to the maximum depths proposed in the current review applications. Cornelly Quarry is to be worked at greater depths than the other quarries, however, the model has simulated the cumulative effects of all quarries being at their maximum proposed depths.

6.6.3 Modelling of the worst possible case indicates that the maximum change of groundwater levels at the Kenfig/Cynffig SAC attributable to the proposed quarry operations will only be 6mm, however, a 12cm change is forecast if pumping to dewater the quarries were to cease immediately on completion of quarrying in several decades time. However, this could be substantially alleviated if pumping at that time was reduced more gradually and in a controlled manner.

6.6.4 Welsh Ministers are of the opinion that the model represents the best scientific knowledge available and that it provides a sound and reliable representation of the behaviour of the aquifer under normal circumstances. Of key concern, however, has been the uncertainty presented by the heterogeneous nature of the carboniferous limestone and the potential for encountering a karstic feature in the limestone beneath the quarries and the behaviour of the water regime as a consequence of dewatering operations.

6.6.5 There are two specific matters concerning uncertainty in the model over which Natural Resources Wales have consistently expressed doubts relative to the integrity of the site [see paragraphs 29-35 and 93-96, Inspectors Report]. These are:

- That some 69% of the water outflow from the model is not specifically accounted for; and,
- The level of uncertainty due to the possible presence of karst features in the geology below the quarries

6.6.6 The model is based on an extensive dataset comprising over 10 years of monitoring data at 105 monitoring points and the model itself has been developed over 15 years in liaison with Natural Resources Wales and its predecessor bodies. The model has been used to simulate the future drawdown circumstances that are likely to occur if and when the quarries are worked to the maximum depths proposed in the current review applications.

6.6.7 Modelling of the worst possible scenario indicates that the maximum change of groundwater will be 6mm, however, a 12cm change is forecast should pumping to dewater the quarries suddenly cease. However, if the final cessation of pumping was carried out gradually and in a controlled manner, the impact on levels at the SAC would be much lower [paragraph 35 Inspector's Report].

6.6.8 Should karstic features (such features can be typically found in limestone and represent a highly permeable conduit for water within the aquifer) be intercepted as the quarry is deepened and widened the model would not represent the resulting unpredictable flows within the aquifer and groundwater levels at the SAC could be lowered to a degree considered to be of detriment to the SAC and its designated features. It is accepted by all parties that it is inherently difficult to model every possible geological scenario due primarily to the heterogeneous nature of the limestone and a degree of uncertainty about the potential hydrological impacts on the SAC will remain.

6.6.9 It is reasonable to accept that the large proportion of water (69%) unaccounted for in the model is due to general outflow towards the coast, but equally, this could be consistent with the presence of an unknown karstic feature. Evidence was put forward by a leading expert on karst geology which concludes that it is highly unlikely that a substantive karst feature would be encountered below the quarries. Natural Resources Wales agree that the risk is low, but because such a risk cannot be ruled out they consider that the potential for an adverse effect on the Kenfig SAC would remain unless this risk is addressed.

6.6.10 Whilst the model does not cover this possibility, it is considered that any assessment should include acknowledgement of that risk [paragraph 153 Inspector's Report]. Recognition has been given to this issue and it has thus been agreed by all parties that suitable mitigation measures which provide identification, mitigation and contingency, could alleviate the potential for an adverse effect on the SAC. Such measures would need to provide an early warning system to detect potential effects and trigger action necessary to alleviate such effects before any adverse changes could occur.

6.7 Impact of further dewatering and the determination of an appropriate threshold for assessing an adverse impact

6.7.1 It is evident that the qualifying features within the SAC are particularly sensitive to long-term changes in baseline groundwater levels.

6.7.2 A significant proportion of the Petalwort SAC features exist at Merthyr Mawr. However, predicted changes to the flow from Burrows Well as a consequences of quarry operation and at the end of the lives of the quarries would not cause any adverse effects on relevant dune slack features at Merthyr Mawr. The key qualifying features of the SAC which may be affected by long term changes in groundwater levels are the dune slacks, dunes with creeping willow, fen orchid, petalwort and the pond at Kenfig.

6.7.3 This agreed threshold for measuring an adverse effect on the SAC was derived from research by Dr Peter Jones, of the former CCW, in 2004 [see paragraph 97 Inspector's Report]. It concluded that "*even slight sustained changes in mean water level of the order of 10cm (or in some cases even less) would be sufficient to result in undesirable transformations from one community to another*". This criterion was used as the basis for the agreed threshold for assessing whether changes to hydrology predicted by the model were likely to be significant. The agreed criterion provides that a 0.1 metre (10cm) or greater difference between actual and expected mean summer water levels in the sand dunes at Kenfig, sustained for 3 consecutive years, would amount to an adverse effect on the designated features of the SAC.

6.7.4 The dune slacks and the pond at Kenfig are already subject to natural seasonal variations and it is common ground that small changes to summer water levels would be unlikely to be detrimental to the SAC features provided the changes were less than 10cm over 3 consecutive years [paragraph 138 Inspector's Report]. Whilst the natural flora is able to withstand seasonal fluctuations, a sustained 0.1 metre (10cm) reduction in groundwater levels would reduce the size of the zone of ecological interest capable of supporting the protected species and would reduce their resilience. Individual communities of plants would be affected resulting in an adverse effect on the SAC. Therefore, the sensitivity involved gives rise to the need for appropriate early warning systems to be put in place.

6.7.5 Although the advice in the Environment Agency's Ecohydrological Guidelines for Wet Dune Habitats, published in 2010, supports the conclusion that small changes in groundwater levels would not significantly affect the key SAC features it would not be appropriate to use changes in composition of the dune/dune slack communities as an indicator of impacts because a variety of factors reflecting the complex relationship between water behaviour on the site and the condition of the dune and dune slack communities will influence changes. In short the Ecohydrological Guidelines are not sensitive enough as an indicator to pick up changes to individual qualifying SAC features, such as petalwort and fen orchid, because adverse changes to individual features may already be set in train before wider community changes are detected.

6.7.6 The modelling work indicates that the agreed criterion would not be exceeded during normal quarry operations despite substantial increases in depths of working. The model does indicate that an exceedance of the criterion could occur if dewatering pumps were turned off immediately as quarry operations ceased but not if controlled reduction in pumping was carried out instead [paragraph 139 Inspector's Report].

6.7.7 It is agreed by all parties that the application of the 0.1 (10cm) over 3 year criterion is an appropriate mechanism for assessing impacts but that sensitivity criteria at each pathway site should be used to determine whether a significant deviation has occurred otherwise the impact would take effect at the same time as the trigger point was reached and there would be no time for planned mitigation or contingency to take place. In other words, an early warning system is required, which would give an early indication that a 0.1m (10cm) criterion, or greater, change could be anticipated in the future.

6.8 Water management plans and effectiveness of mitigation measures

6.8.1 A key concern of Welsh Ministers is that the mitigation and contingency measures are effective given the sensitivity of the Kenfig/Cynffig SAC to potential changes in groundwater levels. A system of monitoring which documents changes without requiring and securing mitigating action which can avoid adverse impacts would not be acceptable. The agreed Water Management Plan needs to ensure the integrity of the SAC is not affected by identifying any negative effects before they occur and it is critical that any required measures can be implemented in time to prevent such impacts manifesting themselves.

6.8.2 The Water Management Plan (WMP) is a tool to ensure the water environment is protected against the possible effects of changes in groundwater levels resulting from the proposed quarrying activities [paragraph 142 Inspector's Report]. The WMP comprises detailed specification of long term monitoring at an extensive network of monitoring sites, arrangements for annual reporting results, the mechanism to identify deviations from expected water levels which would trigger the need for mitigation or contingency measures and proposals for those possible measures.

6.8.3 The Applicants predict that there will be a lowering of the groundwater levels in the dunes to the west of Kenfig Pool of up to 0.12m (12cm) relative to the baseline i.e. a lowering in excess of the agreed 0.1m (10cm) criterion. It is therefore recognised that if this remains unmitigated the result would be an adverse effect on the dune slacks. The shadow appropriate assessment prepared by the Applicants sets out the ecological impact assessments, and these are also referred to in the ecological/hydrological chapters and appendices of the Environmental Statements. However the shadow assessment makes no reference to the 0.1m (10cm) over 3 year criterion which is now referred to in the final versions of the WMPs.

6.8.4 Until the day before the public inquiry there was a difference between the Applicants and NRW on two matters, namely, the definition of an appropriate 'trigger point' based on the monitoring of groundwater levels at the SAC and whether provisions were required or not for the risks associated with encountering a karstic feature (even though this risk was accepted as being very low) [paragraph 143 Inspector's Report].

6.8.5 Agreement has now been reached in relation to these matters. In the agreed WMP (version 8, paragraphs 4.1.1 and 6.4.2) there is now provision for a network of pathway monitoring sites between the quarries and the SAC, rather than just at the SAC itself. This mechanism enables clear triggers for necessary mitigation measures and the picking up of early warning signs of change.

6.8.6 It is intended that impacts will be measured by reference to site specific trigger levels which are specific to each monitoring site (with allowances for climate based assessment criteria). If these levels are exceeded, and unless it can be demonstrated that the change is either a statistical artefact or not attributable to quarry dewatering at one or more of the quarries within the agreed timeframe, then remedial action will be implemented in accord with sections 7 and 8 of the respective WMP.

6.8.7 Data will be collected by the applicants from November to October during the course of a calendar year with reporting to the regulator, the mineral planning authority (Bridgend County Borough Council) in January. The WMP establishes a suite of flexible mitigation measures that can be required by the mineral planning authority (and on the advice of NRW). In order to ensure long term protection, it is intended that the respective WMPs will cover the entire life of the developments. This will be required by the agreed planning conditions.

6.8.8 The low risk of interception of a karstic feature has been resolved by making provision in the WMPs, along with a supporting planning condition, for changes to be incorporated in the future if found to be necessary to deal with such an incident in the unlikely event that it should occur. These provisions acknowledge the rights of the quarry operator under the Environment Act 1995 that no changes would be made that would prevent quarrying operations or otherwise restrict working rights [paragraph 145 Inspector's Report].

6.8.9 It is only when the final version of the WMPs and the final agreed planning conditions are taken into account that the potential for adverse effects on the SAC can be avoided.

6.8.10 As well as assessing the robustness of the mitigation and contingency measures from the technical and scientific perspective, it is necessary to assess the robustness of the mitigation measures from a practical perspective. Measures should be capable of being implemented. Practically, implementation will depend on the ability to access data at all of the monitoring pathway sites so that any significant deviations can be recorded and appropriate action in the form of alternative mitigation taken as necessary.

6.8.11 The production of monitoring data over recent years from many sources beyond the quarry boundary and the receptor site suggests there is no issue with entering onto third party land. This is not referred to specifically in the Inspector's Report but is vital to the successful implementation of the WMP. It has been confirmed by the applicants that they have access arrangements in place to enable them to maintain the monitoring points on land in the ownership/control of third parties. There are contingency measures in place which provide further reassurance.

6.8.12 Another important issue is the statement in section 2.5 of the WMPs that "*No changes requested by the regulator shall, however, have the purpose or effect of stopping or preventing quarry operations or otherwise restricting working rights within the meaning of the Environment Act 1995*".

6.8.13 Whilst this statement would appear to remove the ultimate restriction on operations if a significant deviation is recorded it also removes the possibility of an adverse impact on the economic viability of the site. If such a restriction were placed on operations in the future, then, in accordance with Minerals Planning Guidance Note 14 the developers would have the opportunity to submit a claim for compensation which the mineral planning authority would have to deal with.

6.8.14 The integrity of the Kenfig/Cynffig SAC must be protected and to address an extreme hydrological impact, such as the interception of a karstic feature, it has been agreed by all relevant parties that it is possible to impose a planning condition that enables an alteration of the planned mitigation and contingency measures in order to address an extreme hydrological impact not foreseen by the hydrogeological modelling. Given the low risk of impact overall, it is reasonable to conclude that as a whole the water management measures contained in the WMP and the necessary planning condition would be capable of overcoming any potential problems.

6.9 <u>In combination assessment</u>

6.9.1 With regard to in-combination effects, TAN 5 advises:
"*In considering the combined effects of other plans and projects it will normally be appropriate to take account of outstanding consents that are not started or fully implemented, ongoing activities or operations that are subject to continuing regulation (such as discharge consents or abstraction licences) and other proposals that are subject to a current application for any kind of authorisation, permission, licence or other consent. The effects of projects which have already been implemented and policies and proposals in adopted and published draft plans should also be included in the in-combination test. Thus, the assessment is not confined to proposals that require planning permission, but includes all plans and projects.*"

6.9.2 For the purposes of this assessment, the potential impacts arising from all three quarries, namely Cornelly, Grove and Gaens, have been considered together. This is due to the fact the boundaries abut each other in a tight cluster. All of the historical and current environmental data has been collected and assessed as if the quarries were acting as one operation. With the exception of some historical dewatering from Cornelly to Stormy Down quarry and from Grove quarry to the adjoining old railway cutting water management has largely been contained within the current boundary of the three quarries. Grove quarry has in fact been closed for several years with no dewatering taking place, the accumulated water flooding the void. Some water has been pumped into Grove quarry from Cornelly quarry when the accumulation of water in the water storage areas in Cornelly has reached maximum levels. Hence, the majority of water arising within the quarry voids has been retained within the same geological block.

6.9.3 Two former municipal landfills (dilute and disperse) are located in old quarries to the east and south of Cornelly Quarry. (Stormy West, *sealed, 25m thick, 75m AOD base* and Tythegston *capped, 40m thick, 50m AOD base*). Both landfills contain potential pollutants and the potential of leachate was identified. Stormy Down is now a flooded quarry. It is acknowledged in paragraph 5.6 above that water quality issues would not result in a likely significant effect on the SAC.

6.9.4 There are a number of local licensed abstractions and private water supplies. However, these are not considered to meaningfully combine with the effects of the proposed quarries in a way which could adversely affect the SAC.

6.9.5 In considering the possibility of other in-combination effects it is evident there are no other plans or projects present or proposed in the area which may meaningfully influence or combine to add to the potential effects of the Cornelly group of quarries on the Kenfig/Cynffig SAC. Consequently for the purposes of this appropriate assessment in-combination effects have been limited to the three quarries themselves acting in combination with each other.

7 Integrity Test

7.1 In accordance with Regulation 61(6), Welsh Ministers in considering whether a plan or project will adversely affect the integrity of the SAC, must have regard to the manner in which it is proposed to be carried out or to any conditions.

7.2 The integrity of the site is defined as "*the coherence of its ecological structure and function, across its whole area, which enables it to sustain the habitat, complex of habitats and/or the levels of populations of the species for which it was classified or listed*" (TAN 5). The integrity test can also be considered to be the quality or condition of being whole or complete, or, in a dynamic ecological context as being resilient, with the ability to evolve in ways that are favourable.

7.3 Dune slacks are low-lying areas within dune systems that are seasonally flooded and where nutrient levels are low. They occur primarily on the larger dune systems in the UK, especially in the west and north, where the wetter climate favours their development when compared with the generally warmer and/or drier dune systems of continental Europe. The range of communities found is considerable and depends on the structure of the dune system, the successional stage of the dune slack, the chemical composition of the dune sand, and the prevailing climatic conditions. The Kenfig/Cynffig SAC contains the most important example of Humid dune slacks in the UK, owing to the extent of the habitat type and the conservation of its structure and function.

7.3 The proposed conditions in the applications relating to hydrology and ecology have been agreed by the parties. It is clear that the 0.1m (10cm) change in mean summer groundwater level at the dune slacks is an important criterion even though the sites are subject to higher seasonal variations throughout the year. The qualifying features of the SAC experience natural variation in groundwater levels due to climatic factors and they are adapted to cope with these variable conditions, with the rarer species preferring wetter conditions and the less desirable species (i.e. less desirable compared to safeguarding the rarer species) with which they compete preferring drier conditions. Critically, the natural groundwater fluctuations generally recover or tend back to a stable baseline (of seasonal variation) which supports the special plant communities in the dune slacks.

7.4 If there were to be a sustained fall over several years in the baseline, this would result in a change in the baseline ecology of the dune slacks. The zone of ecological interest capable of supporting the qualifying features would be reduced, affecting the resilience of the dune slack communities because the ability of the species to recover from the background natural fluctuations, especially following drier periods will be diminished. A consequential shift in dune slack communities could result and this would amount to an adverse effect on the integrity of the SAC [paragraphs 99 - 100 Inspector's Report]. The 0.1m (10cm) over 3 years criterion as an agreed measure of adverse effect gives protection to the ecological resilience of the SAC.

7.5 In light of this sensitivity it is the view of Welsh Ministers, therefore, that without the agreed provisions in the WMPs and the imposition of planning conditions the proposed development could adversely affect the integrity of the European site. When the proposed measures and conditions are taken into account any potential adverse effects on the SAC can be ruled out.

7.6 Welsh Ministers consider that the risk of interception of karstic features is extremely low and that the proposed measures and conditions are sufficient to alleviate a potential adverse effect on the integrity of the SAC in this regard and account for the remaining uncertainties associated with the hydrogeological model.

7.8 The conditions relating to the four review applications have been the subject of lengthy discussion and several amendments have been made to address potential impacts. The parties have agreed the final wording of the WMP, along with three conditions required to ensure the WMP (in its present form or a modified form) is implemented over the lives of the quarries and that suitable arrangements are put in place to avoid sudden cessation of pumping at the end of the quarry lives.

7.9 Subject to the provisions of the WMP and the imposition of the agreed planning conditions it is the opinion of Welsh Ministers that the residual uncertainties of the hydrogeological model are adequately covered and that appropriate safeguards are provided for the water environment and the private water supplies in the area. At the same time the WMP now achieves the aim of ensuring that there would be no adverse effect on the integrity of the Kenfig SAC as a result of quarry operations and decommissioning [paragraph 146 Inspector's Report]. Without these agreed conditions, and the associated measures in the Water Management Plans, an adverse effect on the Kenfig/Cynffig SAC cannot be ruled out on the basis of best available scientific evidence.

8 Conclusions

8.1 It is the role of Welsh Ministers, as competent authority in determining these applications, to ensure that the requirements of the Habitats Regulations are met.

8.2 The integrity test is whether there is reasonable scientific doubt, rather than an absolute certainty about the potential for harm to a European site. In this sense an effect would not be adverse if it would not undermine the conservation objectives of the site. Based on the assessment above and the integrity test, it is clear that when taking into account the agreed mitigation and contingency measures Welsh Ministers can be certain that there would not be a sustained change in groundwater levels which would precipitate a loss of qualifying features of the SAC.

8.3 This Appropriate Assessment has sought to summarise the relevant ecological findings, expressly apply the 0.1m (10cm) by 3 year criterion in the context of ecological impacts and evaluate the risks to the SAC in light of proposed conditions. The conclusion of this assessment, subject to the Water Management Plan (version 5.8) for each of the quarries being adopted and implementation being secured by way of the proposed planning conditions, is that Welsh Ministers consider there would not be an adverse effect on the integrity of Kenfig/Cynffig SAC as a result of the proposed future quarrying operations.

Annex 2 Schedule of Planning Conditions: Application C Gaens

A: Definition of Terms

For the purposes of these planning conditions the following words and phrases shall have the meaning given to them below:

i. "ROMP Area" means the area subject to the application submitted to Bridgend County Borough Council under the provisions of Schedule 13 of the Environment Act 1995 for a Review of the planning conditions regulating quarrying operations at Gaens Quarry;

"ROMP Application" means the application submitted to Bridgend County Borough Council under the provisions of Schedule 13 of the Environment Act 1995 for a Review of the planning conditions regulating quarrying operations at Gaens Quarry;

iii "Date of Determination" means the date upon which new conditions subsequent to the applications are finally determined, i.e. the date upon which all proceedings on the applications, including appeals to the Secretary of State and the High Court have been determined, and the time period for any further appeal has expired;

"Emergency" means any circumstances in which the operator has a reasonable cause for apprehending injury to persons or serious damage to property;

"Mineral Planning Authority, (MPA)", means Bridgend County Borough Council, or any successor mineral planning authority;

"The Site", means all that land at Gaens Quarry which is currently within the permitted area of Gaens Quarry, comprising the "ROMP Area"; and

"2014 ES" means the Environmental Statement (ES) submitted in June 2014 in support of the Gaens Quarry ROMP application.

B: Time Limits

Duration

1. The planning permission hereby granted shall expire on the 6th January 2068.

2. On the expiry of the planning permission, all extraction, processing and stockpiling of minerals shall cease and not recommence.

3. No later than 12 months following the expiry of the planning permissions, or the earlier permanent cessation of winning and working of minerals, all plant, machinery and structures shall be dismantled and removed from the site.

4. No later than 12 months following the expiry of the planning permission, or the earlier permanent cessation of winning and working of minerals, the sale and transportation of minerals to and from the site, together with all ancillary manufacturing activities shall cease.

C: Working Programme

5. The winning and working of stone shall be carried out in accordance with the updated quarry development plan ref numbers 3782/02 to 3782/05 inclusive.

6. The sole means of vehicular access to and from the site shall be from Porthcawl Road as defined on Plan Ref. No. 3782/01: Existing Layout.

7. The site access shall be surfaced in permanent materials, and the surface maintained in a good state of repair, and kept free of mud/debris at all times.

8. Except in emergencies to maintain safe quarry working the following shall apply:

    a. No quarry operations, other than water pumping, the servicing/maintenance of plant, and environmental monitoring, shall be carried out at the site except between the following times:

        i. 0600 – 2200 hours Monday to Friday; and
        ii. 0600 – 1600 hours Saturday;

    b. No operations other than environmental monitoring and water pumping at the site shall take place on Sundays or public/bank holidays.

    c. No operations for the formation and subsequent removal of material from bunds/soil storage areas shall be carried out at the site except between the following times:

        i. 0800 – 1800 hours Monday to Friday; and
        ii. 0800 – 1300 hours on Saturdays.

d. Deliveries and collection of aggregates shall only be made between the following times:

   0700 – 1900 hours Monday to Friday
   0700 – 1300 hours Saturday with no deliveries/collections on Sundays or Public /Bank Holidays

e. Within the working hours specified above, temporary operations shall only be carried out between 0800 - 1900 hours Monday to Fridays.

D: Environmental Protection

Hydrology & Hydrogeology

9. The water management, monitoring, reporting, mitigation and contingency activities set out in the Water Management Plan (WMP) for Gaens Quarry v5.8 dated 9th November 2015 shall be carried out throughout the duration of the planning permission and the 5 year aftercare period.

10. In the event that the Minerals Planning Authority requires changes to the WMP, as provided for in the WMP, then the amended water management, monitoring, reporting, mitigation and contingency activities requested by the Minerals Planning Authority shall be carried out for the duration of the planning permission and the 5 year aftercare period.

11. Prior to the cessation of dewatering, a scheme shall be submitted to and approved in writing by the Minerals Planning Authority setting out proposals for residual pumping during the quarry decommissioning stage. The scheme shall include details of the rates and timescale of residual pumping, and the measures to be taken to monitor the effectiveness of the residual pumping during the defined time period. The scheme shall thereafter be implemented in accordance with the approved scheme.

12. Any facilities for storage of oils, fuels or chemicals on the site shall be sited in impervious bases and surrounded by impervious bund walls. The volume of the bunded compound shall be at least equivalent to the capacity of the tank plus 10%. If there is multiple tankage, the compound shall be at least equivalent to the capacity of the largest tank, or the combined capacity of inter-connective tanks, plus 10%. All filling points, vents, gauges and site glasses shall be located within the bund. The drainage system of the bund shall be sealed with no discharge to any water course, land or underground strata.

Associated pipe-work shall be located above ground and protected from accidental damage.

13. Measures shall be taken to minimise the risk of groundwater pollution from quarrying operations, in accordance with the following protocol:

- All mobile plant using fuel should be located on hard standing when not in use;
- All immobile plant using fuel should be located on hard standing. Drip trays should also be appropriately placed under all relevant plant;

- All refuelling activities should be undertaken on areas of hard standing, using appropriate care and attention;

- An incident reporting procedure should be maintained for reporting all site incidents, including pollution events. Suitable emergency responses should also be in place in the event of an incident.
- Appropriate spill kits or other means of controlling accidental spills should be made available on site. Adequate training in the use of such equipment should also be provided;

- A maintenance and inspection programme should be followed in order to check the condition of site equipment and provide early warning of any potential leaks or spills;

- Suitable waste management procedures should be followed to prevent surface pollution resulting from any waste products, fuel containers, chemical drums;

- During site restoration all permanent plant and equipment should be removed from the quarry;

- The use of herbicides and other related chemicals should be restricted both during quarry working and post restoration. Chemical applications should be made at appropriate times, in suitable quantities, so to avoid sub surface contamination.

Nature Conservation

14. Measures shall be taken to minimise disturbance of habitats and interference with species, in accordance with the following protocols:

a. Any large trees or large crevices in undisturbed parts of the quarry shall be inspected for possible bat presence immediately ahead of any tree surgery or quarrying works. Any bats which are identified shall be dealt with in accordance with current legislation and best practice;

b. Clearance of trees and scrub should avoid the main bird nesting season (March to August inclusive);

c. Common reptiles encountered during works should be allowed to leave the immediate works area unharmed, and, if necessary, should be assisted by means of capture and release;

d. Dense ruderal and grassland vegetation should be strimmed and raked away at least 24 hours ahead of earthworking, so as to reduce the attractiveness of the area for reptiles, and encourage them to leave; and

e. Written protocols shall be issued to contractors so that in the event of discovery of bats, nesting birds, badgers or common reptiles, compliance with statutory obligations is ensured.

Landscape

15. Within 12 months of the date of determination of this submission a scheme shall be submitted to and agreed in writing by the MPA detailing the fencing out of Tree Preservation Order woodland adjoining the western boundary of the site. The scheme shall be implemented as agreed in accordance with a timetable to be agreed.

16. Within 12 months of the date of determination of this submission a scheme of landscaping shall be submitted to and approved by the MPA. Such a scheme shall provide for:

    a. The landscaping of all peripheral areas of the quarry which would help to screen quarrying operations from adjoining land/settlement and enhance landscape/wildlife interests. Details such as the cultivation of soils, spacing, density and species shall be provided together with the need for protective tree shelters/rabbit guards as appropriate;

    b. Infill, widening and strengthening of the woodland belt along the western boundary of the proposed quarry void (adjacent to Lamb Row and Rock Cottages as well as adjacent to the weighbridge and offices);

c. The progressive landscaping of quarry benches where possible; and

d. All trees, shrubs and hedges planted in accordance with the approved scheme shall be maintained and any plants which within 5 years of planting die, are removed or become seriously damaged or diseased shall be replaced in the next planting season with others of a similar size and species.

All planting shall be carried out in accordance with the approved scheme within the first planting season following the date of its approval.

17. A minimum 1.3 metre high stockproof and two strand barbed wire fence shall be maintained around the entire site perimeter (with the exception of lockable gates) together with quarry warning signs at 25 metre intervals.

Noise

18. Except for temporary operations, the free-field Equivalent Continuous Noise Level, $L_{Aeq,1\ hour}$ due to operations in the site, shall not exceed the relevant criterion limit specified in Schedule 1 at each nominated dwelling for the periods specified. Measurements taken to verify compliance shall have regard to the effects of extraneous noise and shall be corrected for any such effects.

Schedule 1 Noise Criteria Limits

Location	**06:00-07-00** **Criterion** dB $L_{Aeq, T}$	**07:00-19:00** **Criterion** dB $L_{Aeq, T}$	**19:00-22:00** **Criterion** dB $L_{Aeq, T}$	**22:00-06:00** **Criterion** dB $L_{Aeq, T}$
Rock Cottages	42	50	48	42
Sea View, Mount Pleasant Road	45	50	48	42
Ty Tanglwyst Farm	42	55	48	42

Location	06:00-07-00 Criterion dB $L_{Aeq, T}$	07:00-19:00 Criterion dB $L_{Aeq, T}$	19:00-22:00 Criterion dB $L_{Aeq, T}$	22:00-06:00 Criterion dB $L_{Aeq, T}$
Cornelius Close	42	55	48	42

19. For temporary operations such as site preparation, soil and overburden stripping, bund formation and removal and final restoration, the free-field noise level due to work at the nearest point to each dwelling shall not exceed 67 dB $L_{Aeq, 1 hour}$. Temporary operations shall not exceed a total of eight weeks in any calendar year for work close to any individual noise sensitive properties.

Blasting

20. Except with the written consent of the MPA, or in the case of emergency, blasting operations shall be carried out only between 1000 and 1700 hours Monday to Friday, and only in exceptional circumstances on Saturday and not at all on Sunday and Public/Bank Holidays.

21. Ground vibration as a result of blasting shall not exceed a peak particle velocity of 6mms-1 in 95% of all blasts measured over any six month period, and no individual blast shall exceed a peak particle velocity of 10mms-1 measured at any vibration sensitive location, which is defined as any residential property in the vicinity of the quarry existing at the Date of Determination. The measurements shall be the maximum of three perpendicular directions taken at the ground surface. The monitoring locations shall be agreed with the MPA.

22. No blast shall be undertaken closer than 125m of Rock Cottages until a report has been submitted to and approved in writing by the MPA to demonstrate how the vibration limits specified in Condition 21 will be met. The report shall be carried out by a qualified vibration consultant and shall include the following information:

    a) the predicted vibration levels of the nearest sensitive receptor taking into account the Council's vibration results measured as a PPV on the 5th October 2009 at a proximity of 125m from the blast area which were:

- Longitudinal 14.4mm/s
- Vertical 10.8mm/s
- Transverse 21.6 mm/s; and

b) the design of the blast and the Maximum Instantaneous Charge (MIC) that will be required to achieve the limits specified in Condition 21.

23. A minimum of 24 hrs notice shall be given to the MPA of any blasting that is to be carried out within the Quarry that is closer than 125m to Rock Cottages together with details of the proposed blast design.

24. A minimum of 24 hrs notice shall be given to the MPA of all blasting at the Quarry.

25. All individual blasts shall be designed, managed and implemented to minimise the extent of air overpressure resulting from blasts. Such effort shall have regard to blast design, methods of initiation of blasts, and also as far as practicable to weather conditions prevailing at the time of initiation.

26. Each individual blast shall be monitored by the Operators, to include provision for recording the details and location of the monitoring station; the location of the blast holes within the Site; weather conditions; specification of the blast in terms of MIC; and total charge weight. Records of blast monitoring shall be made available to the MPA upon request. Any complaints which are received shall be logged against each particular blast. In the event that monitoring indicates that the vibration levels set out in condition 21 above have been exceeded, then the Operator shall inform the MPA within two working days, with written confirmation of the steps to be taken to ensure compliance with condition 21.

27. Blasting times shall be clearly advertised at the Quarry, and an audible warning shall be sounded prior to any blasting operations taking place, and shall be sounded again immediately after blasting has finished.

28. There shall be no secondary breakage of stone by the use of explosives.

Dust

29. Automatic vehicle cleaning facilities, including sprays to clean the wheels, underbody and side body of vehicles shall be maintained throughout the operations permitted. Such facilities

shall include the provision of a water recycling system to maximise the use of water supplies.

30. At all times during the carrying out of operations, a water bowser or similar equipment shall be available on site, and be used to minimise the emission of dust from haul roads and access roads within the site, and the processing plant site hard standings.

31. Measures shall be taken to minimise dust emissions from quarrying operations, in accordance with the following protocol:

- Soils and overburden shall not be handled during extreme dry conditions unless the working areas are first dampened down;
- Drilling of shot holes shall be undertaken using drilling rigs fitted with a suitable dust collection system;
- Site roads within the quarry shall be dampened down as appropriate, in accordance with the requirement of conditions 31 and 32;
- The site entrance road shall be maintained by use of a road sweeper which shall operate as required to maintain the surface of the road free of mud and other detritus;
- All lorries, once loaded, shall be sheeted prior to leaving the site, with the exception of any load carrying only plus 75mm size stone;
- The speed of haulage vehicles at the site will be restricted to 10mph;
- All site vehicles will be fitted with upswept exhausts and radiator fan shields;
- Lorries will be loaded so as to avoid spillages;
- All site traffic will be kept to the designated haul routes;
- Any plant spillages will be cleared to avoid accumulations;
- Drop heights will be minimised at loading and discharge points.

Archaeology

32. At least 12 months in advance of the commencement of extraction from Phase 3 (as per Drawing 3782/04) a programme

of archaeological investigation and recording in accordance with a written scheme of investigation shall be carried out by the developer. The written scheme of investigation shall be submitted to and approved in writing by the MPA, and implemented within 6 months of the date of the approval.

33. At least 14 days notice of the commencement of any soil stripping programme shall be given to the MPA and the developer shall afford access at all reasonable times to archaeologists nominated by the MPA who shall be allowed to observe the excavations and record items of interest and finds.

Restoration

34. The development shall proceed in accordance with the concept restoration plan ref numbers M13.128b.D.012 and 011 and the details of interim and final restoration treatments, landscaping, and aftercare, set out in the 2014 ES.

35. Not later than 6th January 2067, or the expiry of six months following the permanent cessation of the winning and working of minerals, whichever is the sooner, the Operator shall submit for the written approval of the MPA, a detailed final restoration scheme, including drawings to illustrate the proposals for the final restoration of the quarry. The final restoration scheme shall be based upon the concept restoration plan ref numbers M13.128b.D.012 and 011, and provide for the site to be restored as a nature conservation bias, with restoration treatment of the benches and faces above the water level which will be formed in the void. The scheme shall include updated predictions of the final rest water level of the lake. The remainder of the site shall be cleared of all plant, machinery, buildings and apparatus in accordance with the requirements of Condition 3. The restoration scheme shall include details of the final re-profiling works for the site, the soil /soil forming material profiles to be established; tree and shrub planting schedules; seeding, fencing and drainage; and a programme and timetable for the implementation of the works.

36. Not later than 6th January 2067, or the expiry of six months following the permanent cessation of the winning and working of minerals, whichever is the sooner, the Operator shall submit for the written approval of the MPA, a detailed aftercare management plan. The management plan shall be in substantial accordance with the details of the final restoration scheme and the principles of the strategic aftercare management strategy set out in Chapter 3.0 of the 2014 ES.

The Planning Inspectorate
Yr Arolygiaeth Gynllunio

Adroddiad	Report
Ymchwiliad a agorwyd ar 10/11/15	Inquiry opened on 10/11/15
Ymweliad â safle a wnaed ar 12/11/15	Site visit made on 12/11/15
gan Clive Nield BSc(Hon), CEng, MICE, MCIWEM, C.WEM	**by Clive Nield BSc(Hon), CEng, MICE, MCIWEM, C.WEM**
Arolygydd a benodir gan Weinidogion Cymru	**an Inspector appointed by the Welsh Ministers**
Dyddiad: 11 Rahgfyr 2015	**Date: 11 December 2015**

Environment Act 1995

Section 96 and Schedules 13 and 14

Review of Old Mineral Permissions (ROMPS) for

Cornelly, Grove and Gaens Quarries

and

Interim Development Order (IDO) Periodic Review for

Cornelly and Grove Quarries

Cyf ffeil/File ref: APP/F6915/X/15/516086, 516087, 516088 & 516089

CONTENTS

Application A: File Ref: APP/F6915/X/15/516086

Site address: Cornelly Quarry, South Cornelly

- The application was called in for decision by the (now) Minister for Environment, Sustainability and Housing, one of the Welsh Ministers, under paragraph 13 of Schedule 13 of the Environment Act 1995, on 29 July 1998.
- The application is made by Cambrian Stone Limited (a Tarmac joint venture company) to Bridgend County Borough Council under paragraph 9 of Schedule 13 of the 1995 Act.
- The application Ref P/97/623/MIN is dated 30 June 1997.
- The application is to determine a scheme of conditions to which the mineral permission for the site is to be subject.
- No specific reason was given for making the direction.
- On the information available at the time of making the direction, and as clarified by subsequent correspondence, the matter on which the Welsh Ministers particularly wish to be informed for the purpose of consideration of the application is the effect of the proposed quarrying operations on the water environment, including the potential for significant effect on the Kenfig Special Area of Conservation.
- The inquiry sat for 3 days on 10-12 November 2015.

Summary of Recommendation: The scheme of conditions, as amended and agreed, be approved.

Application B: File Ref: APP/F6915/X/15/516087

Site address: Grove Quarry, South Cornelly

- The application was called in for decision by the (now) Minister for Environment, Sustainability and Housing, one of the Welsh Ministers, under paragraph 13 of Schedule 13 of the Environment Act 1995, on 29 July 1998.
- The application is made by Pioneer Aggregates Limited under paragraph 9 of Schedule 13 of the 1995 Act to Bridgend County Borough Council.
- The application Ref P/97/618/MIN is dated 26 June 1997.
- The application is to determine a scheme of conditions to which the mineral permission for the site is to be subject.
- No specific reason was given for making the direction.
- The matter on which the Welsh Ministers particularly wish to be informed for the purpose of consideration of the application is the same as for Application A above.

Summary of Recommendation: The scheme of conditions, as amended and agreed, be approved.

Application C: File Ref: APP/F6915/X/15/516088

Site address: Gaens Quarry, South Cornelly

- The application was called in for decision by the (now) Minister for Environment, Sustainability and Housing, one of the Welsh Ministers, under paragraph 13 of Schedule 13 of the Environment Act 1995, on 14 May 1998.
- The application is made by TS Rees Limited under paragraph 9 of Schedule 13 of the 1995 Act to Bridgend County Borough Council.
- The application Ref P/97/85/MIN is dated 27 January 1997.

- The application is to determine a scheme of conditions to which the mineral permission for the site is to be subject.
- No specific reason was given for making the direction.
- The matter on which the Welsh Ministers particularly wish to be informed for the purpose of consideration of the application is the same as for Application A above.

Summary of Recommendation: The scheme of conditions, as amended and agreed, be approved.

Application D: File Ref: APP/F6915/X/15/516089

Site address: Cornelly and Grove Quarries, South Cornelly

- The application was called in for decision by the (now) Minister for Environment, Sustainability and Housing, one of the Welsh Ministers, under paragraph 8 of Schedule 14 of the Environment Act 1995, on 11 February 2010.
- The application is made by Cambrian Stone Limited (in respect of Groves Quarry) and Tarmac (South Western) Limited (in respect of Cornelly Quarry) under paragraph 6 of Schedule 14 of the 1995 Act to Bridgend County Borough Council.
- The application Ref P/09/738 is dated 15 September 2009.
- The application is to determine a scheme of conditions to which the mineral permission for the site is to be subject.
- The reason given for making the direction was that the proposed development raises issues of more than local importance, in particular, issues which may conflict with national planning policy on sites of nature conservation importance.
- The matter on which the Welsh Ministers particularly wish to be informed for the purpose of consideration of the application is the same as for Application A above.

Summary of Recommendation: The scheme of conditions, as amended and agreed, be approved.

Preamble

1. This report includes brief descriptions of the sites and surrounding area, relevant planning policies, the gist of the representations made, my appraisal and conclusions, and my recommendations. Document references are shown in brackets, and in my conclusions the numbers in square brackets indicate the relevant paragraphs of the report. Details of the people who took part in the public inquiry and comprehensive lists of documents are attached at the end of the report. The recommended planning conditions are attached as annexes.

Procedural and Background Matters (ES Volume 1 – Core Document CD2.2)

2. The Planning and Compensation Act 1991 introduced a requirement that quarries benefitting from Interim Development Order (IDO) permissions (i.e. predating the 1948 Act) should be subject to a review to allow the original planning conditions to be updated and replaced with new modern conditions to control future quarrying and restoration. This process was duly followed for the Cornelly/Grove Quarries IDO

permission (which covers part of each quarry – see figures in Appendices 1 & 2 of Doc 16.3), and the former Mid Glamorgan County Council issued an updated schedule of conditions on 21 September 1994 (see Appendix 1.1 in Environmental Statement (ES) Volume 2D - Core Document CD2.6).

3. The Environment Act 1995 introduced a process of periodic reviews of old mineral permissions at 15 year intervals in order to ensure that the planning conditions continue to reflect up to date standards and requirements. Schedule 14 sets out the procedures for the periodic review of IDO permissions, and the current application for the Cornelly/Grove Quarries IDO (Application D) is in accordance with these requirements.

4. Schedule 13 of the Act covers the process for periodic reviews of old mineral planning permissions granted after 1948 (known as ROMP reviews), and Applications A, B and C above (for Cornelly, Grove and Gaens Quarries respectively) are made under this Schedule. All 4 of the permissions will fall due for further periodic review of conditions in 15 years time.

5. The 3 ROMP applications were not formally subject to environmental impact assessment when they were made. However, when requested by the (then) Welsh Office, Environmental Statements were subsequently submitted voluntarily for each application. An Environmental Statement was submitted with the 4^{th} application, the Cornelly/Grove IDO Periodic Review, which falls within the scope of the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999 (SI 1999/293) as modified by the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 2000 (2000/3295). In 2009 the Welsh Government enacted the Town and Country Planning (Environmental Impact Assessment) (Undetermined Reviews of Old Mineral Permissions) (Wales) Regulations 2009, and these apply to the 3 ROMP applications.

6. More recently, the environmental information submitted for all 4 applications has been reviewed, and new Environmental Statements were submitted for each case in June 2014 (Core Documents CD2, 3, 4 & 5, each comprising several volumes as detailed in Document 2). These represent the most up to date application documents and include proposed schedules of conditions and Water Management Plans for each quarry. These ESs were advertised in accordance with the legislation.

7. During the course of the preparations for the public inquiry and at the inquiry itself these schedules of proposed conditions and Water Management Plans have been subject to some variation (as agreed between the Applicants, the Council and NRW). As explained by Tarmac's agent in its letter to PINS (Document 25), public advertisement of this varied environmental information is adequately covered by advertisement of the public inquiry itself, where the varied information is open to public scrutiny.

8. Although the Grove Quarry application was originally submitted in the name of Pioneer Aggregates Limited, its ownership now lies within the Tarmac group, and in recent years the 3 Cornelly and Grove applications have been pursued by Lafarge Tarmac Limited. However, at the opening of the inquiry it was reported that the responsible company is now Tarmac Trading Limited.

9. Natural Resources Wales (and its predecessor organisations) has been consulted regularly by both Welsh Government (and its predecessors) and by the Applicants over the period since the applications were first made and, of course, NRW is a statutory consultee for any appropriate assessment under the Habitats Regulations. In view of the importance attached to the possible effects of future quarrying operations on the water environment, including effects on the nearby Kenfig Special Area of Conservation, NRW has participated fully (as a Rule 6 party) in the procedures for the public inquiry and in the public inquiry itself.

Sites and Surroundings (ESs Volume 1 – CD2.2, CD3.2, CD4.2 & CD5.2)

10. The 3 quarries in question are grouped on land to the east and south-east of South Cornelly and to the south of junction 37 of the M4 motorway (see site location plans at Appendix 1 of Document 16.3 for Cornelly and Grove Quarries and in Volume 3 of the Gaens Quarry ES, Core Document CD5.7, for Gaens Quarry). Cornelly is the largest of the 3 quarries and is bounded by Grove Quarry to the west, Mount Pleasant Road to the south and east, Heol-y-Splot to the north-west with Gaens Quarry beyond, and open countryside towards the motorway to the north. The aerial photographs at Documents 34.1 & 34.2 provide an excellent appreciation of the quarry and its surroundings. I have annotated them to show the M4 motorway and arrows pointing towards the north. The quarry site covers an area of almost 79 hectares, of which the extraction area equates to some 48 hectares.

11. Grove Quarry lies to the west of Cornelly Quarry and is not currently in operation. It is currently one of the disused/former quarries to which water from Cornelly Quarry is pumped (see location plan at Appendix 1 of Document 16.3). It is bounded by Heol-y-Splot to the north with the disused Pant Mawr Quarry beyond and an industrial estate to the north-west, by Cornelly Quarry to the east, and by Porthcawl Road (A4229) to the west and south, which links Porthcawl to the motorway. The Grove ROMP area covers some 12.4 hectares and the Cornelly/Grove IDO area almost 48 hectares, although the total extraction area proposed for Grove Quarry amounts to between 18 and 19 hectares.

12. Gaens Quarry is situated due east of the settlement of South Cornelly with a high ridge between the quarry and nearby houses. The disused/former Pant Mawr Quarry lies to the south-east, and to the north and east there is largely open countryside with Ty Tanglwyst Farm beyond the northern boundary. The ROMP area constitutes some 12.7 hectares of which 11 hectares have been disturbed for extraction (see location plan at ES Volume 3 – CD5.7)

13. The quarries are located on a broad upland limestone plateau ranging in level between 80 m and 108 m AOD, the higher level being at the eastern end of Cornelly Quarry. The surrounding land falls away in all directions. There are 2 internationally designated nature conservation sites within 2 km of the quarries: the Kenfig Special Area of Conservation (SAC) to the west-north-west; and the Cefn Cribwr Grasslands SAC to the north (see the Ecological Designations map, Figure 8.1, in Appendix 8.2 of the ES (Volume 2D) – Core Document CD2.6). The same map shows the locations of Sites of Special Scientific Interest, National Nature Reserves and Sites of Importance for Nature Conservation.

Planning Policy (Documents 16.1 & 17.1, and Volume 1 of each of the ESs {Core Documents CD2.2, CD3.2, CD4.2 & CD5.2})

14. Although the principle of mineral development at these quarries has already been established by the extant planning permissions, development plan and national policies provide guidance on environmental controls and operational practices that need to be enshrined in up to date planning conditions. At the national level Minerals Planning Policy Wales (MPPW) establishes a series of sustainable aims for mineral development, including provision for an adequate supply of minerals whilst protecting landscape features and the environment.

15. Paragraph 34 lists the key issues to be considered when assessing the impact of mineral development: access and traffic generation; noise; control of dust, smoke and fumes; blasting controls; land drainage and impact on groundwater resources; visual intrusion; impact on sites of nature conservation, historic and cultural importance; and provisions for restoration, aftercare and after-use. Planning conditions are appropriate on most of these matters.

16. Minerals Technical Advice Note 1: Aggregates (MTAN1) provides more detailed advice on delivering the policies of MPPW. It includes specific advice on measures to reduce the impacts of quarrying and on planning conditions. The advice on blasting vibration limits and controls, noise limits, dust control measures, landscape and visual impact, site management and restoration proposals is particularly relevant to these applications.

17. Although published in 1995, "Minerals Planning Guidance 14: Environment Act 1995 – review of mineral planning permissions" is also relevant as it gives advice on both the statutory procedures to be followed for such applications and the approach to be adopted to the preparation and consideration of updated planning conditions in the review process.

18. The adopted development plan is the Bridgend Local Development Plan, which was adopted in September 2013. It does not make specific reference to reviews of old mineral permissions but contains policies for general environmental protection covering similar issues to those listed above in MTAN1.

Quarry Proposals (Documents 16.1 & 17.1)

19. Each application includes detailed proposals for working the quarries over the next few decades (see the application plans contained in the ESs: Cornelly ROMP, Groves ROMP and Cornelly/Grove IDO Review in Volume 4 (Core Documents CD 2.8, CD3.8 and CD4.8 respectively); and Gaens ROMP in Volume 3 (Core Document CD5.7). Detailed working proposals are described in Section 3 of Volume 1 of each ES (Core Documents CD2.2, CD3.2, CD4.2 & CD5.2). Whilst working would progress into areas not already quarried in due course (though only within the permission boundaries, of course), the key development feature so far as possible effects on the groundwater environment are concerned is increased depths of working.

20. Cornelly Quarry is currently worked down to a level of about 0 m AOD, and the application proposal is to go to -75 m AOD. This would yield reserves of between 42m

and 45m tonnes which, at the present working rate of about 1m tonnes per year, would take an estimated 42 years (i.e. to 2056).

21. The application proposals for Grove Quarry and Gaens Quarry would involve much shallower maximum depths (-15m AOD for Grove and -20m AOD for Gaens). The resource at Grove Quarry would amount to about 12m tonnes, and it has been estimated that at about 250,000 tonnes per year it would have a notional timescale of some 48 years. However, for consistency with Cornelly Quarry, the proposal is also based on a working life of 42 years.

22. Gaens Quarry has a current output of about 150,000 tonnes per year, and the estimated reserve amounts to some 8m tonnes. This equates to an operational term of about 53-54 years (i.e. to 2068).

23. The quarried limestone is primarily used as an aggregate in the construction industry. However, some 50% of the output of Cornelly Quarry is used to produce sinter, a fine crushed limestone which is an essential constituent in the production of iron and steel (for the removal of impurities). The chemical purity of the limestone is essential for this use, and suitable limestone reserves are only found at a small number of quarries in the UK. The importance of the limestone reserve is reflected in the fact that Tata, the owners of Port Talbot Steelworks, are also the freehold owners of Cornelly Quarry.

Case for Tarmac

The material points are:

Hydrogeological Modelling and Monitoring (Document 14.1)

24. Quarrying operations require dewatering of the working area, which lowers the local water table. As quarrying operations go deeper, the water table is lowered even further and there is potential for this hydrogeological effect to encompass a wider area. Cornelly is the deepest of the quarries, and it is proposed to deepen it further over the coming decades. Thus the dewatering of that quarry has the most significant effect and has been investigated in considerable detail. However, the cumulative effect of dewatering all 3 quarries at the same time has also been investigated.

25. It is pertinent that the water removed from the quarries is not lost to the aquifer below but merely redistributed. At present water from Cornelly Quarry is pumped to the adjoining Grove Quarry (which is currently disused). In the past it has been pumped to the disused Pant Mawr Quarry to the north-west of Cornelly or to the disused Stormy Down Quarry to the east (see site location plan at Appendix 1 of Document 16.3). When it was operating Grove Quarry was pumped periodically to a disused railway cutting to the west. Any surplus water from Gaens Quarry goes to the northern quarry sump.

26. Hydrogeological concerns were raised at the time of the original applications, and extensive and widespread studies and investigations have been carried out over many years to address them. These have provided data to enable the aquifer to be modelled and to provide forecast data based on simulation of the proposed future operations.

27. The process started with investigation of the local hydrogeology: conditions at depth below the quarries; the hydraulic connection between the limestone and the dune systems at Kenfig and Merthyr Mawr; the identification of the main outflows from the aquifer; and the feasibility of water management options at the quarries. This led to development of the conceptual model, including the geological and hydrogeological frameworks and the water balance and boundaries, which is a tool for communicating understanding of the groundwater systems at the site. The model has been iteratively refined over the past 15 years in liaison with NRW (and its predecessors), and it is common ground that it represents the best scientific knowledge available and is a robust basis for assessing and managing the risks to the local water environment.

28. The next step was development of a groundwater model based on the conceptual model, and again this has been an iterative process with calibration against the extensive baseline dataset of groundwater levels and flows. Data has been collected (and continues to be collected) from some 105 local monitoring locations, the most extensive hydrometric dataset around any quarry in the UK. The sensitivity of the groundwater model has also been tested. As more data has been collected over the years (most of the datasets go back more than 10 years) the understanding and confidence in the groundwater model has increased, including the groundwater storage, the directions and rates of groundwater flow and connections within and between geological formations.

29. In the Statements of Common Ground between the Applicants and NRW (Documents 18.1 & 18.2) it is confirmed that NRW agrees with both the methods and results of the Applicants' hydrogeological impact assessments. However, NRW has expressed doubts on 2 particular matters. The first is that some 69% of the water outflow from the model is not specifically accounted for. However, this is believed to be due to general flows to the south and west towards the sea and is not considered to affect the understanding of the links between the quarries and the Kenfig SAC. The second is the level of uncertainty due to the possible presence of karst features in the geology below the quarries.

30. Karst features are highly permeable discontinuities that could provide conduits for high groundwater flows if intercepted by quarrying activities. A study carried out by the British Geological Society (BGS) for the National Assembly for Wales in 2000 (Core Document CD6.1) advised that karst features would be likely to exist beneath the quarry floor and, if encountered by deeper quarrying, could be reactivated and produce substantial water flows into the quarry. NRW's concerns are based on that report and on its own guidance document, Hydrogeological Impact Appraisal for Dewatering Abstractions, dated 2007, in which Appendix 3 deals specifically with Karst (Core Document CD6.21). However, more recent investigations have been carried out for the Applicants and indicate a far more positive picture.

31. Investigations carried out in 2003 and updated in 2013 (Appendix H of ES Volume 2A - Core Document CD2.3) included detailed surveys of the exposed quarry faces and 1000 metres of borehole records, substantially more data than available to the BGS in 2000. The conclusion was that the present phase of karst development only extended downwards about 40 metres from the surface, i.e. to about 60 m AOD, coincident with the pre-dewatered level of the water table. The study also showed that there is little

evidence of any substantive karst conduit network. Rather, due to the very high frequency of dilated joints, the dewatered saturated zone appears to be characterised by diffuse fracture flow, and so is more amenable to reliable groundwater modelling than most karstic aquifers.

32. Taken together with the relatively low pumping rates experienced at Cornelly Quarry, even though the groundwater level is drawn down by some 60 metres, and the steep gradients found in groundwater levels in the area, this suggests that there is a very low probability of encountering significant zones of enhanced permeability (i.e. active karst conduits) as the quarry is deepened further. This contradicts the conclusions of the BGS assessment in 2000 which are now considered by Tarmac to be incorrect.

33. The findings of these studies should be given considerable weight as they were carried out by Professor Peter Smart who is one of the UK's leading experts on karst geology. It is also pertinent that Professor Smart was one of the authors of the karst chapter in the other document referred to by NRW, the 2007 guidance document on Hydrogeological Impact Appraisal for Dewatering Abstractions (Core Document CD6.21). The Applicants are of the view that, on the basis of Professor Smart's conclusions, a high level of confidence can be placed in the modelling work and that NRW's view that there remains a degree of uncertainty due to the possibility of encountering karst features is misplaced.

34. The key criterion so far as effects on the Kenfig SAC is concerned is the water level regime in the dune slacks (as explained below). The hydrogeological model has been used to simulate the effects of deepening the quarries and to assess the potential impacts on the dune slack groundwater levels. Although a range of simulations have been carried out, the most illustrative is modelling the situation of maximum water table drawdown at the quarries. This shows a worst case prediction of a 6 mm change in general water level at the Kenfig SAC, a prediction accepted by NRW in the Statements of Common Ground (Documents 18.1 & 18.2). It should also be born in mind that this assessment is based on an instantaneous change of water levels at the quarries rather than a gradual change over several decades, a very precautionary approach.

35. In contrast, the modelling predicts a maximum water level change of 12 cm at the SAC if pumping at the quarries were stopped suddenly at the maximum excavated depths (without any mitigation measures). However, if the final cessation of pumping was carried out gradually and in a controlled manner, the impact on levels at the SAC would be much lower. This is one of the matters dealt with in the Water Management Plan.

Water Management Plan (Documents 14.1, 18.1 & 18.2)

36. At the opening of the inquiry the Applicants and NRW announced that they had reached agreement on the wording of the Water Management Plan (Documents 19.1-19.6), which is to be incorporated by agreed conditions, and that compliance with the WMP would ensure there would be no adverse effect on the SAC. Up to that time, whilst there was little between the parties, it had not been possible to reach complete agreement.

37. The WMP is a tool for protecting the water environment and local private water supplies. It consists of: quarry pumping arrangements; requirements for long-term future monitoring of the extensive network of monitoring sites; requirements for review and reporting of the data each year, including overview by the Council (in conjunction with NRW); the mechanism for identifying whether a deviation from the specified assessment criteria (trigger levels) has occurred, the cause and significance of that deviation, and what adjustments should be made; planned mitigation measures, such as changes to the destinations for quarry pumping or modification or compensation arrangements for an affected private water supply; and contingency measures should unpredicted events occur. (Document 19.1)

38. Prior to agreement being reached there were 2 significant matters between the parties. The first was about how to identify a trigger event at the SAC receptor site. It is common ground that the measure to be adopted for a significant effect on the integrity of the SAC (see below) should be a 0.1 m drawdown in summer water levels over a 3 year period, and the Applicants had taken this to be an appropriate trigger for identification of the need for mitigation measures. However, NRW's view was that the trigger should 0.1 m change over just one year as, if that drawdown were to occur over a 3 year period, there would already have been a significant impact on the SAC.

39. However, that impasse has been overcome by specifying changes in levels at pathway monitoring sites as the measures to trigger actions, and this is the approach adopted in the final WMPs. The hydrogeological model has been used to assess appropriate deviations from the expected norms at each of the identified intermediate pathway sites equivalent to a deviation of 0.1 m at the SAC (see Table 1 in Document 22). It can be seen that these are substantially greater than any deviations expected at those monitoring sites under normal circumstances and so would be readily apparent. A further advantage of this approach is that it would give advance warning of possible impacts at the SAC itself as there would be delays of several years between identifying deviations at these sites and the effect reaching the SAC (see last columns on Table 1). Thus there would be adequate time to take mitigation or contingency measures to ensure the criterion of 0.1 m deviation over 3 years for significant harm to the SAC was avoided.

40. The second key issue was the degree of precaution to be allowed for in the contingency measures, as NRW was concerned about the risk of encountering karst features. The Applicants did not want to entertain any provisions within the WMP that might have the effect of stopping or restricting quarrying operations or otherwise restricting working rights, as the Act makes provision for any such constraints to be applied by means of special Modification Orders, which come with provisions for financial compensation to the quarry operator. This matter has been resolved by including within the WMP an acknowledgement (in paragraph 2.5) that *"the WMP may need to be revised from time to time"* and that *"No changes .... shall, however, have the purpose or effect of stopping or preventing quarry operations or otherwise restricting working rights within the meaning of the Environment Act 1995"*.

41. The final position now is that all parties agree that the contingency measures in version 5.8 of the WMP are adequate and that the WMP as a whole provides the necessary

assurance to safeguard the water environment (and hence the SAC features) and private water supplies in the area from significant harm.

Effect on Special Area of Conservation (Document 15.1)

42. This section is headed in the singular as it is only the effects on the Kenfig SAC that need to be considered in any detail. The Cefn Cribwr Grasslands SAC (to the north of the quarries), which has purple moor grass (*Molinia*) meadows and the marsh fritillary butterfly as qualifying features, is not dependent on groundwater features that could be affected by dewatering of the Cornelly group of quarries. Consequently there is no mechanism by which the quarry proposals could have a significant effect on the SAC, and there is no need to make any further appropriate assessment under the Habitats Regulations. That is common ground with NRW.

43. The Kenfig SAC is made up of 2 discrete areas, the Kenfig dunes (and pond) and the Merthyr Mawr dunes (see the Ecological Designations map, Figure 8.1, in Appendix 8.2 of the ES (Volume 2D) – Core Document CD2.6). The key features for consideration are the dune slacks, which are dependent on water levels for their integrity. Dune slacks are damp or wet hollows left between the dunes where the groundwater reaches or approaches the surface of the sand. Their most distinguishing feature is a seasonally fluctuating water table which usually reaches a maximum in winter and spring and a minimum in summer, and vegetation development is strongly associated with the average depth and seasonal fluctuation of the water table. (Document 14.1)

44. Kenfig Pool is also identified as a qualifying SAC feature and any reduction in groundwater levels could reduce the size of the pool and the available habitat for the qualifying species (the benthic vegetation of *Chara* species). It is common ground with NRW that an appropriate measure of significant impact on both types of SAC features would be a change in summer groundwater levels of 0.1 m over a rolling 3 year period. This is based on studies of the Kenfig dune slacks carried out by Peter Jones of CCW and reported in a short paper in 2004 (Core Document CD6.25). He reported that dune slack communities were differentiated by their summer water regimes and that differences as small as 10 cm (i.e. 0.1 m) separated many communities. He recommended that, pending further research, 10 cm be adopted as an interim figure to aid impact assessment.

45. The groundwater modelling work has demonstrated that, even at the depth of quarrying proposed several decades ahead, the impact of quarry operations on summer groundwater levels at the SAC would be considerably less than 10 cm and would not have any significant effect on the integrity of the SAC. The Statements of Common Ground between the Applicants and NRW (Documents 18.1 & 18.2) record agreement that, subject to implementation of the WMP (v5.8), there would be no adverse impact on the integrity of the SAC. There is also agreement that the 0.1 m criterion provides the necessary degree of resilience.

46. Although not given much weight by NRW, consideration has also been given to the advice in the Environment Agency's Ecohydrological Guidelines for Wet Dune Habitats, published in 2010 (Core Document CD6.22). The guidelines state that their purpose is to *"provide a generic tool to help conceptualise wetlands and inform assessments of whether vegetation communities associated with European-designated wet dune*

features should be considered at risk of being out of regime. For example, they may be used for the purposes of impact assessments for new consents under the Habitats Directive or more generally". In view of the organisations and authors involved in preparing the guidelines and the use of the Kenfig SAC as one of the underlying case studies, it is reasonable to take these into account in assessing impacts on the SAC in this case.

47. Table 3.1 of the Guidelines details water table conditions for defining the different types of humid dune slack habitats, and these further support the conclusion that changes to the water level regime of less than 0.1 m would be insufficient to move any of the dune slack habitats in the SAC from one sub-category to another or to adversely affect the benthic vegetation of *Chara* species in the Kenfig Pool.

Appropriate Assessment (Documents 15.1 & 31 and Core Document CD2.6)

48. The Applicants are of the opinion that appropriate assessment under the Habitats Regulations is unnecessary for Kenfig SAC as it is straightforward for the competent authority (in this case the Welsh Ministers) to decide that the project is not *"likely to have a significant effect on a European site"* (the test in paragraph 61(1) of the Habitats Regulations) and would not *"adversely affect the integrity of the European site"* (the test in paragraph 61(5) of the Regulations). Thus further assessment is not considered to be necessary. This view is reached in the light of the recent Supreme Court judgement in *Regina (Champion) v North Norfolk District Council and another [2015] UKSC 52* (Court of Appeal decision is at Document 32.1 and Supreme Court decision is at Document 32.2) and in full knowledge of the well known *Waddenzee* judgement (*Landelijke Vereniging tot Behoud van de Waddenzee v Staatsscretaris van Lanbouw (Coöperatieve Producentenorganisatie van de Nederlandse Kokkelvisserji UA intervening) (Case C-127/02) EU:C:2004:482; [2005] All ER (EC) 354; [2004]ECR I-7405, ECJ*).

49. The Applicant's barrister has included a summary of the key points taken from the Supreme Court judgement at Appendix 1 of his closing statement (Document 31) but further highlighted the following principles:

- No decision has yet been made by the Welsh Ministers on whether appropriate assessment is needed or not, and so it can still make that decision.
- It is now common ground amongst the parties, including NRW, that, with the provisions of the WMP and agreed conditions, the proposals would not have a significant effect on the SAC.
- As all of the information is available, including NRW's agreement, to enable the Welsh Ministers to be able to be confident that the SAC would be protected at this initial stage, no further appropriate assessment is required.
- The Regulations and Directive do not set out any formal requirements for the content or form of an appropriate assessment.
- It would be perfectly lawful for the Welsh Ministers to conclude that appropriate assessment is not required as it is already able to reach a positive conclusion on the

test in paragraph 61(5) of the Regulations, i.e. that the project would not *"adversely affect the integrity of the European site"*.

50. However, notwithstanding this position, if the decision maker considers it necessary to carry out an appropriate assessment, the information required is provided in the shadow appropriate assessment (SAA) at Appendix 8.3 of the ES Volume 2D (Core Document CD2.6). Section 2 of the SAA sets out the assessment process and explains that for the first step, the decision as to whether appropriate assessment is needed or not, the term "likely" is taken in its broadest meaning as "capable", i.e. "is the project capable of having a significant effect on the SAC". Thus the likelihood of an effect needs only to be very low to trigger the need for an appropriate assessment.

51. Section 3 of the SAA describes the qualifying interests of the Kenfig SAC and their criteria for favourable conservation status, and Section 4 carries out the first step review concluding that "it is not possible to rule out the likelihood that the quarrying operations will have a significant effect on the (Kenfig) European site". The same section rules out at this step the possibility of affecting the Cefn Cribwr Grasslands SAC. Sections 5 and 6 of the SAA then go on to identify what features of the SAC might be affected by changes in the water level regime and what those predicted effects might be.

52. The key habitats are identified as the dune slacks, which are hollows within the dune systems that form between the dune ridges, where the plant species are adapted to the seasonally changing groundwater levels and are therefore sensitive to any long-term alteration of such cycles. These include petalwort and fen orchid, 2 rare plant species which are qualifying features of the SAC in their own right. The other relevant SAC feature is the Kenfig Pool with a benthic vegetation of *Chara* species, a form of algae that resembles land plants and is commonly known as stonewarts.

53. The SAA makes reference to the Ecohydrological Guidelines for Wet Dune Habitats, published by the Environment Agency in May 2010 (Core Document CD6.22), which provide guidance on the range of water table conditions required to sustain the various types of dune slack habitats and which identify the summer maximum values as the most relevant, as they represent the period when the water table is at its seasonal lowest. The extensive groundwater modelling carried out by the Applicants has predicted a maximum change in groundwater level due to the proposed quarrying of only 6 mm at both the dunes and Kenfig Pond. Such a change would be insufficient to shift any of the dune slack habitats from one sub-category into another. It would also be much lower than the 0.1 m change criterion adopted by NRW, based on Peter Jones' research work reported in 2004 (see Core Document CD6.25).

54. The only predicted exception to this is that during decommissioning of the quarries, if the quarry dewatering pumps were completely turned off and this coincided with a drought, a fall in groundwater levels by as much as 0.12 m could occur. Whilst it is marginal whether this would be sufficient to materially affect the dune slack habitats, it would exceed the 0.1 m change prescribed by NRW. However, it could be substantially alleviated if residual pumping were continued for a period after quarrying ceased, and this could be ensured by applying appropriate planning conditions, as agreed with NRW in the Statements of Common Ground (Documents 18.1 & 18.2) and the Version 5.8 WMP (Documents 19.1-19.6).

55. NRW has continued to express concern about risks associated with possible interception of a highly permeable karst feature and, whilst the risk is very low, it cannot be completely ruled out. However, as explained above, this small risk can be adequately covered by the inclusion of contingency measures in the WMP and appropriate planning conditions, as agreed with NRW and described in the Statements of Common Ground. Paragraph 61(6) of the Habitats Regulations says that *"In considering whether a plan or project will adversely affect the integrity of the site, the authority must have regard to the manner in which it is proposed to be carried out or to any conditions or restrictions subject to which they propose that the consent, permission or other authorisation should be given"*. Thus the appropriate assessment takes into account the safeguards contained in the WMPs and proposed planning conditions. The assessment has also taken into account the in-combination effects of all of the quarries operating at the same time.

56. Section 7 of the SAA reaches the conclusion that, taking account of the WMPs and proposed planning conditions, there would be no adverse effect on the integrity of the SAC arising from the proposed continuation of quarrying or the recovery stage after decommissioning. NRW agrees with this conclusion (see Statements of Common Ground at Documents 18.1 & 18.2).

57. The information provided is sufficient to enable the Welsh Government to carry out an appropriate assessment if it considers it necessary to do so.

Other Matters (Document 16.1)

58. There is common ground between Tarmac and the Council on all other matters (Document 3), and it is agreed that the proposed planning conditions can provide appropriate controls or mitigation measures on all of the following matters:

- on-site ecological matters, including the potential for biodiversity enhancements in the restoration scheme;
- landscape and visual impact, with additional screen planting in certain locations;
- noise limits at sensitive properties around the sites in accordance with current standards;
- blast vibration limits at sensitive properties in accordance with current standards;
- dust control measures to avoid potential impact on neighbouring land uses and amenity (in addition to controls included in the PPC permits);
- highway impact issues; and
- progressive restoration and long-term restoration of the sites.

59. The Environmental Statements have considered all of these matters and concluded that none significantly affect the abilities to continue to mine the quarry reserves. This assessment has been guided by the relevant national and development plan policies. National policy recognises that mineral extraction can only take place where the mineral is found to occur, that its extraction is a temporary operation (albeit often over many years), and that any adverse effects on amenity and the environment need to be

mitigated to acceptable levels. The proposed planning conditions would achieve these requirements.

60. Several matters have been raised by interested third parties, though the limited number of such responses also gives a clear indication that the presence of the quarries is generally well accepted in the local community, which recognises the benefits they bring, and of the well managed nature of the Cornelly and Grove quarries.

61. Some of the third party comments seem to relate to Gaens Quarry rather than the Cornelly and Grove Quarries, and TS Rees responds to these. However, some general matters warrant comment. Firstly, there are concerns about dust. Comprehensive air quality and dust studies have been carried out to inform the Environmental Statements, including dust monitoring. The studies concluded that national air quality standards would not be exceeded and that planning condition controls are capable of minimising dust emissions to within acceptable levels for amenity purposes.

62. Another party was concerned about possible effects of lowered groundwater levels on their farm borehole. All water supply boreholes in the area have been included in the groundwater modelling studies, and the conclusion for the borehole concerned (at Ty Tanglwyst Farm to the north of the quarries) is that any effects will be negligible. However, the borehole will be monitored on a monthly basis (using data loggers) as part of the monitoring regime enshrined in the WMP and would be subject to mitigation measures should unforeseen circumstances arise. The WMP makes provision for modification of private boreholes, the provision of an alternative mains water supply or financial compensation for loss of the supply should such an event arise.

Proposed Conditions (Documents 3, 16.1 & 18.1)

63. Finally, some mention of the proposed conditions is needed. These reflect the recommendations for mitigation measures emanating from the various technical studies for the ESs and up to date national guidance. The 1995 Act requires applicants to submit a schedule of conditions for consideration, and proposals were submitted with the original applications. However, these have been reviewed in the light of the latest ESs (June 2014) and discussions with the Council, and sets of proposed conditions for each of the applications are included as appendices to the Statement of Common Ground agreed with the Council (Document 3). In addition, several conditions have been agreed with NRW on hydrogeological matters (see Statement of Common Ground – Document 18.1). The proposed conditions are considered to satisfy the 6 tests for conditions set out in Welsh Government Circular 16/2014, The Use of Planning Conditions for Development Management.

64. The proposed schedule of noise criteria limits in the noise condition warrants particular explanation. This adopts noise limits measured at noise sensitive properties of 55 dB $L_{Aeq, 1 hour}$ for daytime hours (0700-1900 hours) and 42 dB $L_{Aeq, 1 hour}$ for night-time hours (2200-0600 hours). However, following the discussion on conditions held during the inquiry, Tarmac agrees that a lower daytime limit of 50 dB $L_{Aeq, 1 hour}$ should be adopted for Cornelly Quarry at Rock Cottages and Sea View, properties that otherwise enjoy a relatively quiet background noise environment (Closing Statement – Document 31).

65. The schedule includes compromise noise limits for the intermediate hours 0600-0700 and 1900-2200 hours. At present there are no restrictions on site working hours, and these are intended to provide a constructive compromise to reflect recent working practices. When the applications were made MPG11 (Minerals Planning Guidance: The Control of Noise at Surface Mineral Workings), issued in 1993 by the DOE and the Welsh Office, was extant and included the following advice:

"35. In some local circumstances, it may be appropriate for an evening period, typically 1900-2200 hours, and/or a dawn period, typically 0600-0700 hours, to be defined. If evening and/or dawn periods are to be defined, depending on local circumstances, limits modified from those indicated at paragraph 34 should be set." (Paragraph 34 specified the 42 and 55 dBA limits referred to above.)

66. Although MPG11 is no longer extant and MTAN1 makes no mention of these evening and dawn periods, this is the approach taken in this case. The Council agrees with this approach, and it is commended as a compromise that is beneficial to local amenity. The limits proposed for 0600-0700 hours are the lowest achievable, being set at 42, 45 or 48 dBA at different properties. The limit proposed for 1900-2200 hours is 48 dBA (a correction of the figures included in the sets of conditions attached to the Statement of Common Ground).

67. Updated schedules of planning conditions for the 3 Tarmac applications, taking into account the discussion on conditions held at the inquiry, were submitted on the final day of the inquiry (Documents 26.1-26.6).

Case for TS Rees

The material points are:

Hydrogeology and Special Area of Conservation

68. TS Rees relies on the same case as put forward above for Tarmac in respect of the hydrogeological modelling and monitoring, effect on the SAC, Water Management Plan and appropriate assessment. The specialist evidence submitted on these matters was prepared on behalf of both Tarmac and TS Rees.

Appropriate Assessment (Document 30)

69. TS Rees supports Tarmac's contention that appropriate assessment under the Habitats Regulations is unnecessary, though if it is carried out, all of the information necessary is available in the shadow habitats regulations assessment (available in the Gaens ROMP Environmental Statement at Appendix 6.9 in Volume 2D - Core Document CD5.6) and in the wider ES. In support of the shadow assessment, NRW is of the opinion that, subject to the controls and provisions provided by the WMP and related planning conditions, there would be no adverse effect on the integrity of the Kenfig SAC due to quarry operations (see Statement of Common Ground – Core Document CD18.2).

70. Like Tarmac, TS Rees refers to the recent Supreme Court judgement on *Regina (Champion) v North Norfolk District Council and another [2015] UKSC 52* (Document 32.2). That judgement includes the following comments: *"there is nothing in the*

language of the Habitats Directive to support a separate stage of "screening" in any formal sense" (paragraph 37); *"there is no suggestion that this imposes any separate legal obligation analogous to EIA screening"* (38); the issue *"ultimately rests on the judgement of the authority"* (41); and *"the competent authority, in common with their expert consultees, were satisfied that any material risk of significant effects on the SAC had been eliminated. Although this was expressed by the officers as a finding that no appropriate assessment under article 6(3) was required, there is no reason to think that the conclusion would have been any different if they had decided from the outset that appropriate assessment was required, and the investigation had been carried out in that context"* (42).

71. In the current case the issues are not being considered at an early stage in the decision making process but at the final stage when the simple question is "having regard to the totality of the known information, including that from NRW, is there likely to be a significant effect on the integrity of the SAC?" If the answer is "no", then there is no need for further appropriate assessment.

Blasting and Vibration (Documents 17.1 & 17.3)

72. As recorded in the Statement of Common Ground (Document 4), there is only one area of disagreement with the Council, the appropriate controls needed for blasting operations in parts of the site near to sensitive properties, particularly the residential properties, 1 and 2 Rock Cottages (see plan at Appendix 1 of Document 17.1 or Receptor Location R9 on the Receptor Locations Plan at Appendix 10.2 of ES Volume 2D – Core Document CD5.6).

73. TS Rees has proposed a suite of conditions to ensure adequate control of blasting operations at the quarry following a thorough assessment of potential impacts on the amenity of residents nearby (see Chapter 9 of the Gaens Quarry ES – Core Document CD5.2, and the Schedule of Conditions in the Statement of Common Ground – Document 4). These are in accordance with the latest good practice and follow the standards for vibration set out in Minerals Technical Advice Note (Wales) 1: Aggregates (MTAN1). However, the Council is seeking to further constrain the use of blasting in the part of the site nearest to Rock Cottages, following a single regrettable incident in 2009.

74. In October 2009 a single blasting operation some 125 m from Rock Cottages caused levels of vibration measured at the properties in excess of the permitted levels (and the levels now proposed in the planning conditions). An investigation of the incident was carried out by a specialist consultant who concluded that the charges had been properly designed and implemented, and the incident was attributed to some geological discontinuity. Some 40 blasts have been carried out at the quarry since that time without any exceedance of the permitted vibration levels, though these have all been further away from the properties concerned.

75. To safeguard against this in the future the Council is now arguing for a buffer zone to be defined so that blasting would not be able to be employed nearer to Rock Cottages. Clearly that would not be acceptable to the Applicant as it would effectively sterilise a substantial part of the quarry reserves, and any condition along those lines would not be reasonable or necessary, 2 of the 6 tests prescribed for planning conditions.

Furthermore, it would not be reasonable to sterilise the mineral within the buffer zone without serving a notice as a prelude to compensation, as allowed for in the 1995 Act. The ROMP provisions provide a safeguard that the new schedule of conditions should not prejudice to an unreasonable degree either the economic viability of the quarry or its asset value. If they would, then a modification notice must be issued, and provisions for compensation would follow. (See paragraph 80 onwards in Minerals Planning Guidance 14: Environment Act 1995: review of mineral planning permissions – Core Document CD1.5).

76. At Gaens Quarry, there is no need for such a restriction. In the first place, it is not planned that the area of quarry concerned would be worked until Phase 3 of the proposed quarry operations, i.e. for another 25-30 years (and this is covered by one of the proposed conditions). By that time the quarry will have been subject to at least one and possibly even 2 further reviews of conditions and methods for the winning and working of minerals may have evolved by then.

77. Furthermore, rather than prohibit normal operational techniques completely, it would be entirely reasonable to require some assurance that any blasting proposed in that part of the quarry could be carried out without causing unacceptable levels of vibration. This could be done by the operator carrying out more detailed investigations of the localised geology to minimise uncertainty and to put forward for the Council's approval specific proposals and designs for any future blasting work in the area closer to Rock Cottages. This could be achieved by a suitable additional condition broadly along the lines of the condition put forward by the Council at the public inquiry (see Document 20).

78. It is not appropriate for the Council to be too involved in the day-to-day management of the quarry. However, it is entirely reasonable for it to wish to be convinced that any blasting could be carried out without harm to the amenity of nearby residents. The production of a suitable report in due course, based on detailed investigation of the geology in that part of the quarry, would aim to demonstrate that the limits for vibration at nearby residential properties could be achieved so that the minerals in that part of the quarry could be successfully worked using carefully designed charges. It is agreed that it would also be reasonable to require the operator to give advance warning of all such blasts so that they could be suitably monitored.

Other Matters of Concern to Third Parties (Documents 4 & 17.1)

79. Several other matters have been raised by local residents. The first is the possibility of groundwater drawdown affecting a water supply borehole at Ty Tanglwyst Farm to the north of the quarry (see map at Appendix 1 of Document 17.1). The hydrogeological modelling has indicated that, even at the proposed increased depths of quarrying, the effects on water levels in this borehole are expected to be negligible. Indeed, some small rise in level is expected as a result of the proposed water management arrangements.

80. Furthermore, the borehole will continue to be monitored regularly in accordance with the WMP and any changes in water level not expected, bearing in mind the climatic conditions, would trigger intervention and mitigation measures if needed. These trigger conditions are defined in the WMP, and the measured data would be subject to annual

review by the planning authority (advised and assisted by NRW). These various measures will safeguard the borehole or, should an extreme unforeseen event occur, make provision for an alternative supply and/or compensation.

81. With regard to dust, the site would be subject to controls under both the planning permission and the environmental permit. The current planning permission does not include any such conditions. The proposed new conditions would follow national good practice guidelines to minimise the incidence of dust, and studies have been carried out to identify all potential sources of dust at the site, including the access road and internal haul roads which are the main sources of dust generation. Compliance with the proposed new conditions will minimise dust emissions and satisfactorily address the amenity concerns raised by local residents.

82. The access road for Gaens Quarry is from Porthcawl Road and is close to residential properties. HGV vehicles travel in and out of the site regularly throughout the working day with potential for generating noise and dust. However, it is not proposed to increase the rate of quarrying or the number of HGVs travelling in and out of the site each day. So there will be no increase in noise. As for dust, a condition is proposed for lorries to be sheeted prior to leaving the site as part of the measures for minimising dust generation.

83. Overall, the proposed schedule of conditions will provide proper control of site operations with the aim of minimising all impacts on local amenity, providing environmental protection and nature conservation, and making proper provision for landscaping and long-term restoration of the site.

Case for Bridgend CBC

The material points are:

84. The Council defers to Natural Resources Wales in respect of the hydrogeological matters and effects on the SAC. It puts forward no evidence on these matters itself.

General Planning Matters (Documents 3, 4 and 10)

85. The Council has agreed all matters with Tarmac in respect of the applications for Cornelly and Grove Quarries. The Statement of Common Ground (Document 3) includes schedules of agreed conditions for each of the 3 applications.

86. The Council has also agreed all matters with TS Rees in respect of Gaens Quarry except the need for additional conditions to limit the risks of blasting causing excessive levels of vibration in the part of the quarry nearest to Rock Cottages. The Statement of Common Ground (Document 4) includes a schedule of agreed conditions for the Gaens Quarry application, subject only to reservations in respect of Condition 20 on ground vibration limits. On all other matters the Council accepts the conclusions of the ES and that the proposed conditions would provide adequate control of the mineral working development.

Blasting at Gaens Quarry (Documents 11.1 & 11.2)

87. There have been several incidents in the past when blasting operations at the quarry have given rise to levels of vibration considered to cause nuisance to nearby residential

properties. An abatement notice was served on the Company in 1994 and was re-served in July 2006 as a result of complaints received by the Council. The 2006 notice was served to ensure that the latest advice on acceptable levels of vibration, as contained in MTAN1, was used by the operator in the design of future blasting. However, in October 2009 these levels were exceeded in a blast conducted at a location some 125 m from Rock Cottages (see map at Appendix 1 of Document 17.1 for locations of nearby sensitive properties). MTAN1 advises that vibration should not exceed 6 mm/s in 95% of all blasts measured over a 6 months period and that no individual blast should exceed 10 mm/s. The 2009 blast was measured well in excess of the latter, and a formal caution was subsequently served on the Company.

88. The boundary for the Gaens Quarry ROMP site passes within 15 metres of Rock Cottages, and the Council is highly sceptical that blasting could be acceptably employed for mineral working that close to the properties when a blast 125 m away is capable of causing such excessive levels of vibration. Investigations into the 2009 incident confirmed that the blast had been properly designed and executed, and the only plausible explanation seems to be that the excessive vibration was due to some unexpected geological transmission path.

89. The quarry operator has not carried out any blasting within 125 m of Rock Cottages since that incident, and the Council's initial approach to the current ROMP application was that a buffer zone should be established to protect the nearest sensitive properties from risks of excessive vibration. However, in the light of the Applicant's evidence, the Council has put forward suggested additional conditions (Document 20) requiring a specialist expert investigation and report to demonstrate the feasibility of blasting in that part of the quarry before further mineral working is carried out there, assurance that individual blasts have been appropriately designed and advance warning of any such blasts.

90. Provided conditions along these lines are included, the Council is in agreement with the full schedule of proposed conditions.

Case for Natural Resources Wales

The material points are:

91. Natural Resources Wales (and its predecessor bodies) has been consulted by and has provided advice to the Welsh Government (and its predecessors) on a regular basis since the applications were called in. Over that period it has also provided advice to the Applicants in regard to the hydrogeological modelling work and possible implications for the SAC. Full agreement was reached with the Applicants shortly before the opening of the public inquiry and is reflected in agreed Statements of Common Ground with each Applicant (Documents 18.1 & 18.2) and the agreed Water Management Plan (Documents 19.1-19.6).

Hydrogeological Modelling (Documents 12.1, 12.2, 18.1 & 18.2)

92. It is agreed that the hydrogeological modelling carried out by the Applicants through their conceptual and groundwater models, as explained in detail in the ESs, is sound and based on over 10 years monitoring over a wide network of locations. In the ordinary course of events NRW is satisfied that it provides a reliable representation of

the groundwater system around the quarries. However, a degree of uncertainty remains in respect of 2 matters.

93. The first uncertainty is about the potential hydrogeological impacts on the Kenfig SAC due to the generally heterogeneous nature of the carboniferous limestone aquifer in which the quarries are situated and the possibility of encountering a highly permeable karstic feature within the aquifer as the bases of the quarries are lowered. Karstic features are formed during geological periods when there is significant groundwater flow through the rock. The limestone is dissolved by rainfall, soil water and groundwater, which are all slightly acidic, so that enlarged fractures are created, and these form highly permeable conduits for groundwater flow. Whilst they are usually surrounded by much larger volumes of low permeable limestone, if quarry excavation encounters a karstic feature, significant groundwater flow can occur.

94. The Environment Agency's research report, Hydrogeological Impact Appraisal for Dewatering Abstractions (Core Document CD6.21), advises: *"given the high vulnerability of karstified aquifers and the considerable difficulties in predicting the effects of groundwater abstractions in them, the precautionary principle indicates that groundwater systems developed in these rock types should be considered as karstified until this is proven not to be the case"*. The British Geological Society report prepared in 2000 for the (then) National Assembly for Wales (Core Document CD6.1) advised that karstic features are likely to exist beneath the quarry floors and, although Professor Peter Smart's report for the Applicants in 2013 (Appendix H of ES Appendix 7.1 (Volume 2A) - Core Document CD2.3) expresses more confidence about not encountering such features, a degree of uncertainty still remains.

95. The second matter is the degree of uncertainty in the water balance calculations. Some 69% of the aggregate water discharge from the aquifers within the study area has not been accounted for or fully analysed. The Applicants believe this to be on account of wide dispersion of flows towards the coast but it could also be caused by a more highly concentrated discharge via, for example, submarine springs, which would be consistent with the presence of highly permeable karstic features. This raises further doubts about the possibility of encountering such features.

96. Thus, whilst NRW agrees with the conclusions of the Applicants' hydrogeological assessments which indicate that the probability of intercepting a highly permeable karstic feature with potential to cause an adverse effect on the Kenfig SAC is extremely low, the modelling cannot completely rule out the risk and the consequent impacts on the SAC as a result of deepening (and widening) the quarries.

Effect on Special Area of Conservation (Documents 13.1, 13.2, 18.1 & 18.2)

97. The protected features at the Kenfig SAC are highly sensitive to even small changes in the groundwater level regimes, even though levels vary considerably with the seasons. All parties accept the conclusions in Peter Jones 2004 paper, The Influence of Hydrological Processes upon the Structure and Composition of Dune Slack Vegetation, (Core Document CD6.25), which was based on many years of extensive research into the hydrological conditions of the Kenfig SAC. The paper's conclusion that *"even slight sustained changes in mean water level of the order of 10 cm (or in some cases even less) would be sufficient to result in undesirable transformations from one community*

to another" provides the basis for an agreed quantitative threshold for a likely adverse impact on the ecology of the SAC. The agreed threshold is set out in the Statements of Common Ground and provides that a 0.1 m or greater difference between actual and expected mean summer water levels in the dune slacks, sustained for 3 consecutive years, would amount to an adverse effect on the ecology of the SAC.

98. Contrary to Tarmac's suggestion, NRW has not changed its position on this definition for an adverse impact on the SAC. Its suggestion that a 0.1 m variation over just one year should act as a trigger within the water management regime was aimed at ensuring that a potential adverse effect on the SAC (i.e. 3 consecutive years) would be addressed before it occurred. If the trigger had been set at 0.1 m variation over 3 consecutive years it would have been too late as, by definition, the adverse effect would have already occurred. However, this point has now been addressed to NRW's satisfaction by the "early warning system" now provided for in the WMP by using changes at the pathway monitoring sites as triggers.

99. The 0.1 m change in mean summer groundwater level at the dune slacks is an important criterion even though the sites are subject to higher seasonal variations throughout the year (see sketches at Document 21). The SAC features experience natural variation in groundwater levels due to climatic factors and they are adapted to cope with these variable conditions, with the rarer species preferring wetter conditions and the less desirable species (i.e. less desirable in terms of safeguarding the rarer species) with which they compete preferring drier conditions. Critically, the natural groundwater fluctuations generally recover or tend back to a stable baseline (of seasonal variation) which supports the special plant communities in the dune slacks.

100. NRW's concern is that, if there were a sustained 0.1 m fall over several years in the baseline, it would result in a change in the baseline ecology of the dune slacks. A sustained 0.1 m reduction between actual and expected mean summer water levels would reduce the size of the zone of ecological interest capable of supporting the protected species and would reduce their resilience. Effectively, it would increase the time taken for the feature species to recover from the background natural fluctuations, particularly following drier periods. A baseline change of 0.1 m caused by the quarry activities would be likely to produce a shift in the dune slack communities from one type of community to another and so would amount to an adverse effect on the integrity of the SAC. This is the basis for adopting a 0.1 m change over 3 consecutive years as the agreed measure of adverse effect on the integrity of the SAC.

101. In the light of this level of sensitivity, whilst it is accepted that quarrying operations are unlikely to result in a significant hydrological event, the agreed mitigation and contingency measures contained within the WMP are necessary to remedy any unexpected events, and this needs to be reinforced by several conditions.

Water Management Plan (Documents 13.1, 13.2, 18.1, 18.2 & 19.1-19.6)

102. The parties have now reached agreement on the content and provisions of the WMP, the purpose of which is to ensure that the quarry operations do not cause any adverse effect on the integrity of the SAC attributes. The WMP sets up a framework for monitoring the groundwater network and for mitigation measures if unexpected changes occur. Water levels will be measured at pathway sites, i.e. sites between the

quarries and potential receptors at the SAC, in order to provide early warning of potential impacts, as well as at monitoring points at the SAC itself. This will allow time for suitable mitigation measures to be implemented before harm is caused to the SAC.

103. The impacts at each monitoring point will be measured by reference to site specific trigger levels (with allowances for climate based assessment criteria, i.e. to reflect what is expected as a result of climatic variations). If these triggers or criteria are exceeded and the discrepancy is attributed to dewatering operations at the quarries, then appropriate remedial action will be required. The trigger levels will be set at precautionary values to provide an early indication of changes in the groundwater regime and an early indication of a potential for groundwater level reductions of the order of 0.1 m at the SAC dune slacks. Any significant deviations would trigger the need for mitigation measures to avoid significant effects on the SAC.

104. The WMP includes an annual timetable for the collection and reporting of the monitoring data, and the latest version of the WMP now requires data collected between November and October of the next year to be reported in the following January so that any deviation in the critical summer water levels can be identified at the earliest possible opportunity. Sections 7 and 8 of the WMP establish a suite of flexible mitigation measures and contingency measures which may be required to ensure there is no impact on the SAC.

105. In addition to the WMP several conditions are also needed (and have been agreed in the Statements of Common Ground) to secure the implementation of the WMP for the life of the development, though it should be emphasised that none of the requirements of the WMP or the conditions would have the purpose or effect of preventing quarrying or otherwise restricting working rights within the meaning of the 1995 Act. It is agreed that risks to the SAC can be adequately addressed by way of the proposed planning conditions.

106. It is common ground that the conditions are necessary to secure the implementation of the WMP and to ensure there is no adverse impact on the integrity of the SAC. The WMP includes provision for alteration of the planned mitigation measures and contingency measures in order to address extreme hydrological impacts which the hydrogeological modelling has not foreseen or made provision for. Together with the agreed additional planning conditions (see section 4 of the Statements of Common Ground), the WMP now adequately addresses the residual uncertainties of the model.

Appropriate Assessment (Documents 13.1, 13.2, 18.1 & 18.2)

107. Regulation 61 of the Conservation of Habitats and Species Regulations 2010 requires the decision maker to consider whether appropriate assessment of the development's impact on the SAC is required. NRW's view is that it is required as, until agreement was reached just before the opening of the inquiry on the need for conditions to secure the implementation of the WMPs and because the measures contained within the WMP are necessary to safeguard the integrity of the SAC, the possibility of causing harm to the SAC could not previously be ruled out. In addition, without those additional measures, a groundwater level change of more than 0.1 m was predicted to occur at the SAC during the quarry decommissioning phase (i.e. when pumping ceased), which would have a significant impact on the SAC. Until agreement was reached with the

Applicants shortly before the opening of the public inquiry, NRW was not satisfied that the identified risks to the SAC and the residual uncertainty in the model had been suitably addressed, such that the risk remained that the schemes would adversely affect the integrity of the SAC. Only when the proposed conditions are taken into account can the likely effects be ruled out. These factors need to be considered through the process of appropriate assessment.

108. The Applicants are of the opinion that appropriate assessment is not necessary and have referred to the recent Supreme Court judgement on *Regina (Champion) v North Norfolk District Council and another [2015] UKSC 52* to support that contention. However, NRW does not agree with that argument for several reasons.

109. Firstly, *Champion* is not authority for this contention as it did not deal directly with this matter. It addressed 2 specific issues: the correct approach to the timing of EIA screening: and whether or not and to what extent mitigation measures may be taken into account in EIA screening. The only mention of Habitats Regulation 61 is: *"It is said to be common ground that mitigation measures may be considered as part of the process of appropriate assessment once it has been decided following screening that appropriate assessment should be carried out"*, which provides clear support for the approach advocated by NRW. Whilst there is no formal screening stage in appropriate assessment, unlike Environmental Impact Assessment, there is a clear distinction between the requirements of regulations 61(1) and 61(5), the one requiring consideration of whether the plan or project is "likely to have a significant effect on the protected site", and the other whether the plan or project will "adversely affect the integrity of the site".

110. Secondly, *Champion* is distinguishable from the current applications as in that case the conditions being considered were not "necessary" to eliminate the risk of an adverse effect on a European site. The Supreme Court took the view that in that case the Council had applied the conditions for purposes of reassurance rather than as a necessity to safeguard the SAC. That is different from the current applications where the conditions (and WMP provisions) are necessary to ensure there would be no adverse effect on the dune slacks of the SAC, and that is common ground amongst the parties. In the light of this distinction and the fact that the Supreme Court did not specifically address the issue of mitigation measures in the context of the Habitats Regulations, the ruling in *Champion* cannot be read across to the current applications.

111. Thirdly, there is also a good policy reason for NRW's view that appropriate assessment needs to be carried out. Some of the applications under consideration have taken 18 years to reach a public inquiry during which time a considerable amount of work has been carried out and extensive paperwork has been generated. A clear appropriate assessment would bring this to a conclusion so far as the requirements of the Habitats Regulations are concerned and would avoid the need for any interested party to follow a paper chase should they wish to be satisfied it had been properly addressed.

112. As for the appropriate assessment itself, all parties agree that there is sufficient information for it to be carried out and on what the conclusion of the assessment should be. There is sufficient information in the shadow appropriate assessment contained within the ESs at Appendix 8.3 (Volume 2D – Core Document CD2.6), within

the wider ESs and in the WMP. The appropriate assessment should summarise the ecological findings, expressly apply the 0.1 m over 3 consecutive years criterion in the context of the ecological impacts, and evaluate the risks to the SAC in the light of the agreed conditions and WMP provisions.

113. No special procedure or particular form is prescribed for an appropriate assessment, and it is NRW's view that, given the extensive assessment work already carried out, the appropriate assessment can be a simple and straightforward process. It may be said that the best appropriate assessment may be quite brief. As to the conclusion, NRW's view is that, provided the WMP (version 5.8) for each of the quarries is adopted and their implementation is secured by way of the proposed conditions, there is unlikely to be any risk of an adverse impact on the Kenfig SAC as a result of the proposed quarrying operations. Consequently, there is no reason on hydrological or ecological grounds why the applications should not be approved.

114. Finally, the Cefn Cribwr Grasslands SAC warrants mention. NRW agrees with the Applicants' assessment that there is no mechanism by which the quarry proposals could possibly have a significant effect on this SAC and there is no need for any further assessment.

Other Third Party Representations

115. Two local residents gave evidence at the public inquiry, Messrs Peter Vincent and Clive Tranter, and a letter was handed in from Mr & Mrs Nicholas (local residents). In addition, letters were received before the inquiry from Mr Rhys Lougher (a local farmer), Ms Janet Roberts (local resident) and Cadw.

The material points are:

116. Mr Vincent is a member of the local residents association and of the quarries liaison committee and spoke to a written statement (Document 23). He lives at Rock Cottages which, together with the houses at Railway Terrace, are the houses closest to Gaens Quarry. An attractive escarpment and wooded area lies between Rock Cottages and the quarry. It is subject to a tree preservation order and is believed to be a site of special scientific interest due to its ancient woodland and rare plants. It should not be disturbed by quarrying too close to it.

117. The immediate vicinity of Rock Cottages used to be a small medieval settlement called Tomsville. It has the remains of a small medieval chapel, Ty Capel, and ancient human remains have been found in the gardens. The Glamorgan-Gwent Archaeological Trust has carried out a dig there.

118. The prospect of blasting in the part of the quarry nearest to these properties is of great concern. Problems have been experienced on several occasions in the past, with reported cracks to walls, floors and ceilings and damage to wall tiles and crockery. The most recent incident was only about 2 years ago. Many residents find the blasting incidents disturbing and, even, frightening, and they affect elderly residents, animals and property values (in terms of their attractiveness).

119. Problems are also experienced with dust, and this is particularly keen in dry weather with an easterly wind. Cars, windows and steps become coated in dust, and doors and

windows cannot be left open. Effects on heath are also of concern, and many residents suffer bronchial and chest complaints.

120. Mr Tranter lives at Ty Maen House (see plan at Appendix 1 of Document 17.1), a Grade II listed building in the village. A blast about 2 years ago caused a considerable shock, shook the house and caused tiles to fall off the bathroom wall. Mr Tranter reported it to the Council.

121. Mr & Mrs Nicholas live at Railway Terrace (see plan at Appendix 1 of Document 17.1) and handed in a letter to the inquiry (Document 24). Whilst attention has been given to effects on Rock Cottages and other properties, Railway Terrace seems to have been barely recognised, yet it is one of the nearest groups of houses to the proposed extension of Gaens Quarry (i.e. the north-western part of the quarry where little working has been carried out in recent years). Problems are already experienced with high levels of noise and dust, and these will get worse. The South Cornelly Nursing Home is just to the rear of Railway Terrace and is also affected.

122. Disturbance due to blasting has also been a serious issue, and the Council has visited many times to carry out monitoring of blast vibrations, though often abortively when blasting has not been carried out as advised. The effects of blasting operations seem to be quite variable, sometimes affecting one property and sometimes another, presumably due to inconsistent geological features. Mineral Development Policy ENV11 (of the Bridgend Local Development Plan) sets a list of criteria to be met by mineral developments. Many of these would certainly be breached by the proposed extension of Gaens Quarry.

123. Mr Lougher farms Ty Tanglwyst farm to the north of Gaens Quarry (see plan at Appendix 1 of Document 17.1), and is concerned about possible effects on his water supply borehole. A sustainable water source is essential to the running of his dairy farm, which employs 16 people. It requires a substantial volume of water and, if this had to be purchased from the public water undertaking, would involve significant extra costs to the business, which might make it unviable. As the quarry workings go deeper and more groundwater is pumped out to facilitate this, Mr Lougher is concerned about the borehole running dry.

124. Ms Roberts lives in South Cornelly close to the entrance to Gaens Quarry and is concerned about dust. Every day she has to wipe dust off the clothes line and outside furniture, and it even affects furniture inside the house. Since moving to the area she has suffered from a chest complaint for which a diagnosis is awaited.

125. Finally CADW has responded to a consultation invitation under its role associated with designated historic assets. It advises that there are 2 Grade II listed buildings nearby in South Cornelly: Ty Maen, a Mid 17th Century 2-bay house; and the garden gateway at Ty Maen. As the applications relate only to reviews of the planning conditions within the existing quarry site boundaries they would not have a significant visual impact on the setting or character of these listed buildings. The proposals would not impact on any designated assets or raise issues of more than local importance in relation to the historic environment.

Conditions

126. Towards the end of the public inquiry I held an open discussion on conditions, considering the detailed wording and terms of each of the proposed conditions. Some are common to all 4 schedules but others are specific to each application. The schedules considered comprised those contained in the Statements of Common Ground with the Council (Documents 3 & 4), those in the Statements of Common Ground with NRW (Documents 18.1 & 18.2) and, for Gaens Quarry, the extra conditions on blasting put forward by the Council (Document 20).

127. The time limits for each case reflect the anticipated life of the mineral asset at the present rate of working, and the other conditions in Section B would ensure clearance of the site at that time. The conditions in Section C, Working Programme, would ensure future operations are carried out in accordance with the development plans detailed in the Environmental Statements and that working hours would reflect current good practice guidelines (and current practices at each quarry), subject to some limited compromise to take into account the current, largely unfettered controls applied to the quarries.

128. The rest of the conditions, Section D, provide controls for environmental protection. The first group cover hydrology and hydrogeology, and it was agreed that the draft condition on compliance with the Water Management Plan (WMP) should be replaced by the 3 conditions in the NRW Statements of Common Ground, which would ensure: compliance with the WMP throughout the life of the development; compliance with any future amended version of the WMP for the remaining life of the development; and provision for a residual pumping scheme during the eventual decommissioning stage.

129. Two conditions are included to safeguard general ecological matters, followed by a group of conditions specific to each quarry for improved landscaping measures (such as boundary screening). Those are followed by conditions on noise limits, which generally follow the advice in MTAN1, except that compromise limits are set for early morning and evening work where such hours of work are normal practice at those quarries (and currently not otherwise regulated). Corrections were agreed to the schedule for those quarries in respect of the noise limits for the evening period (1900-2200 hours), as incorrect higher limits had been included in error. In addition, it was agreed that the daytime noise limits would be reduced to 50 dB $L_{Aeq\ 1\ hour}$ for the properties Rock Cottages and Sea View for consistency amongst the quarries and to reflect the quiet background noise levels at these properties.

130. Each schedule then includes a group of conditions to control blasting, which reflect good practice and the advice in MTAN1. In addition, for Gaens Quarry it was agreed that 3 extra conditions should be included to address the concerns about the feasibility of using blasting in the part of the quarry close to Rock Cottages. These cover the carrying out of geological investigations and submission of a report to demonstrate that blasting is feasible in this area without causing unacceptable levels of vibration at the nearby residential properties, the submission of blast design details in advance of any such blasting in that area, and the provision of 24 hours notice for any blasting in the quarry as a whole.

131. Each schedule then includes conditions to ensure good practice is followed in measures to control and minimise the generation of dust, and finally several conditions aimed at ensuring restoration of the quarries when the winning and working of minerals eventually ceases, with reference to the proposed schemes in the Environmental Statements, including landscaping and aftercare arrangements.

132. Following the discussion on conditions, both Applicants have helpfully provided revised schedules of conditions to reflect the agreed changes (Documents 26.1-26.3 as plain versions for the 3 Tarmac applications for Cornelly and Grove Quarries, Documents 26.4-26.6 as tracked-change versions of those, and Document 27 for the TS Rees application for Gaens Quarry). It is common ground that these schedules of conditions address the matters intended by the 1995 Act and that they meet the tests for planning conditions set out in the conditions Circular (WGC 016/2014, The Use of Planning Conditions for Development Management).

Conclusions

[The numbers in square brackets indicate the relevant paragraphs of the report.]

133. In my view the main considerations in these applications are: the degree of reliance that can be placed on the Applicants' hydrogeological modelling; the likely effect of further dewatering of the quarries on the Kenfig Special Area of Conservation (SAC); the degree of reliance that can be placed on the Water Management Plan for the life of the quarries; and whether or not one can have confidence that future quarry operations would not adversely affect the integrity of the Kenfig SAC. For Gaens Quarry an additional consideration is whether or not future blasting in the part of the quarry closest to residential properties can be adequately controlled to avoid unacceptable levels of vibration at those sensitive properties. [13]

Hydrogeological Modelling

134. The aquifer model produced by the Applicants is based on an extensive dataset comprising over 10 years monitoring data at some 105 local monitoring points, the most extensive hydrometric dataset around any quarry in the UK. The model has been developed over a period of almost 15 years in liaison with Natural Resources Wales and it predecessor bodies using iterative techniques as the dataset has increased and the understanding of the behaviour of the aquifer has improved. It represents the best scientific knowledge available, and it is common ground that it provides a sound and reliable representation of the behaviour of the aquifer under normal circumstances. [9, 26-28, 91, 92]

135. It has been used to simulate the future groundwater drawdown circumstances that are likely to occur if and when the quarries (and particularly Cornelly Quarry) are worked down to the maximum depths proposed in the current applications. The proposal is to excavate Cornelly Quarry to a considerably greater depth than the other quarries. However, the modelling has also simulated the cumulative effects of all quarries being at their maximum proposed depths. Modelling of the worst possible case indicates that the maximum change of groundwater levels at the Kenfig SAC attributable to the proposed quarry operations will be only about 6 mm, though a 12 mm change is forecast if pumping to dewater the quarries were to cease immediately on completion of quarrying in several decades time. However, this could be substantially alleviated if pumping at that time was reduced more gradually and in a controlled manner. These model results are accepted by NRW as reasonable representations for assessment of potential effects on the SAC. [19-21, 24, 25]

136. The only difference between the parties is in the assessment of the risks of encountering a karstic feature (i.e. a highly permeable conduit for water within the aquifer) as the quarries are deepened. If this were to occur the model would not be representative of the resulting unpredictable flows within the aquifer, and there would be a risk of lowering groundwater levels at the SAC to a degree detrimental to the SAC. NRW's concerns are based on the well accepted likelihood of karstic features being present in limestone rocks, the conclusion to this effect in the BGS study carried out for the (then) National Assembly for Wales in 2000, and the large proportion of outflow water unaccounted for (69%) in the hydrogeological model. Although the Applicants'

explanation that this is due to general outflow towards the coast is perfectly reasonable, NRW submits that it could also indicate the presence of a highly concentrated discharge somewhere, which could be consistent with the presence of an unknown karstic feature. [29, 30, 93-95]

137. In response, the Applicants have provided evidence based on a detailed study carried out by Professor Peter Smart, one of the UK's leading experts in karst geology, the conclusion of which is that substantive karstic features are highly unlikely to be encountered below the quarries. NRW accepts this assessment but argues that the risk cannot be completely ruled out. I draw the same conclusion. Whilst I consider there to be a high level of confidence in the modelling work carried out and in the reliability of the model under normal circumstances, one cannot entirely rule out the risk of a highly permeable karstic feature being encountered. However, as explained below, this risk can be managed by the proposed Water Management Plan. [30-33, 94, 96]

Effect on Special Area of Conservation

138. Putting that risk to one side for the time being, it is common ground that small changes in groundwater levels would be unlikely to be detrimental to the SAC provided the changes to summer water levels were less than 10 cm over 3 consecutive years. The key qualifying features of the SAC that might be affected by long-term changes in groundwater levels are the dune slacks and the pond at Kenfig. These already experience natural seasonal variations in groundwater levels but longer term changes would cause changes to the baseline ecology and harm to key features. [43, 44, 97, 99, 100]

139. The measure of 10 cm change to summer levels over 3 consecutive years is based on the results of studies on the Kenfig dunes carried out by Peter Jones of the former CCW and reported in 2004; it is not in dispute. The modelling work indicates that this measure would not be exceeded during normal quarry operations despite substantial increases in depths of working. The model also indicates that a slight exceedance could occur if dewatering pumps were turned off immediately quarry operations ceased but not if controlled reduction in pumping was carried out instead. This could be ensured by a suitable planning condition. [34, 35, 44, 45, 54, 97, 99]

140. The Applicants have also taken into account the advice in the Environment Agency's Ecohydrological Guidelines for Wet Dune Habitats, published in 2010, which were intended to be used for assessments of this sort. These describe the different types of dune slack habitats and provide further support for the conclusion that the small changes in groundwater levels due to quarrying operations predicted by the modelling work would not significantly affect the key SAC features. I consider these provide valuable confirmation of the assessment based on the simple criterion of 10 cm change over 3 years. [46, 47, 53]

141. The only circumstances not covered by the modelling results are, of course, the unlikely possibility of a karstic feature being encountered. However, the WMP makes provision for this scenario. Thus it is common ground that, subject to implementation of the measures in the WMP and to appropriate conditions, the proposed quarry operations would be highly unlikely to have an adverse impact on the designated features of the SAC. I agree with that conclusion. [45, 98, 101]

Water Management Plan

142. The Water Management Plan (WMP) is a tool to ensure the water environment (and hence the SAC) and local private water supplies are adequately protected against possible effects of the changes in groundwater levels resulting from future quarry operations. It comprises detailed specification of long-term monitoring at an extensive network of monitoring sites, arrangements for annual reporting of results, the mechanism to identify deviations from expected water levels which would trigger the need for mitigation or contingency measures, and proposals for those possible measures. [37]

143. Until the day before the public inquiry there was a difference between the Applicants and NRW on 2 matters: definition of an appropriate "trigger point" based on the monitoring of groundwater levels at the SAC and whether provisions were required or not for the risks associated with encountering a karstic feature (even though this risk was accepted as being very low). However, these differences have now been resolved. [36, 38, 102]

144. The "trigger point" issue has been resolved by adopting a network of pathway monitoring sites (i.e. sites part of the way between the quarries and the SAC), rather than relying on monitoring data only at the SAC itself, and defining triggers at each site based on the degree of deviation from the expected groundwater levels. Not only will this method provide clear and agreed triggers to identify the need for mitigation measures to avoid harm to the integrity of the SAC, but it will also provide a much earlier warning to ensure mitigation measures were carried out in good time. [39, 102-104]

145. The karstic feature issue has been resolved by making provision in the WMP, along with a supporting condition, for changes to be incorporated in the WMP in the future if found to be necessary to deal with such an incident in the (agreed) highly unlikely event of it occurring. The provisions also acknowledge the rights of the quarry operators under the 1995 Act that no changes would be made that would prevent quarrying operations or otherwise restrict the working rights without the formal issue of a notice involving compensation to the operators. [40, 98, 105]

146. The parties have now agreed the detailed wording of the WMP, along with 3 conditions required to ensure the WMP (in its present form or a modified form) is implemented over the lives of the quarries and that suitable arrangements are put in place in due course to avoid sudden ceasing of pumping at the end of the quarry lives. Subject to the provisions of the WMP and the planning conditions, it is now common ground that the residual uncertainties of the hydrogeological model are adequately covered and that appropriate safeguards are provided for the water environment and the private water supply boreholes in the area. The WMP now achieves its aim of ensuring that the water environment is safeguarded against any significant detrimental effects arising from quarry operations. [41, 62, 79, 80, 106, 123]

Appropriate Assessment

147. The parties disagree on whether or not appropriate assessment under the Conservation of Habitats and Species Regulations 2010 is required but are in agreement that there is sufficient information available for such an assessment and that, whether or not a formal assessment is carried out, the proposed schemes (including the provisions included in the WMP and in planning conditions) will not adversely affect the integrity of the SAC. [48, 69, 107]

148. In arguing that appropriate assessment is not required the Applicants have made reference to the recent *Champion* judgement (*Regina (Champion) v North Norfolk District Council and another [2015] UKSC 52*). They submit that, as the Regulations do not specify a formal screening stage (unlike EIA) or any requirements for the content or form of an appropriate assessment, the matter rests on the judgement of the competent authority (in this case the Welsh Ministers). Furthermore, as all of the information needed is available, the decision maker is able to take into account the proposed mitigation measures and reach the conclusion that the project (or cumulative projects) would not *"adversely affect the integrity of the European site"*, the test prescribed in Regulation 61(5) of the Regulations. In *Champion* the Court took the view that, in the circumstances of that case, it would have made no difference if the conclusion that significant effects on the SAC had been eliminated had been reached at the initial stage or after formal appropriate assessment. Thus it is submitted that in the current case a positive conclusion can be reached on the initial assessment, and it would be perfectly lawful not to go on to any formal appropriate assessment. [48, 49, 70, 71, 108]

149. NRW disagrees with this interpretation and argues that: firstly, *Champion* does not deal directly with assessment under the Habitats Regulations as its primary issues are in connection with EIA screening, and so it cannot be relied upon for interpretation of the Habitats Regulations; secondly, that the circumstances of that case were quite different from the current ones as the decision maker did not rely on conditions being necessary to eliminate the risk of adverse effects on the SAC; and thirdly, that some formal record is needed in the current case to ensure any interested party did not have to follow a paper chase extending over 18 years to be satisfied the Regulations had been properly considered. Furthermore, it is established in law, principally in the *Waddenzee* judgement (*Landelijke Vereniging tot Behoud van de Waddenzee v Staatsscretaris van Lanbouw (Coöperatieve Producentenorganisatie van de Nederlandse Kokkelvisserji UA intervening) (Case C-127/02) EU:C:2004:482; [2005] All ER (EC) 354; [2004]ECR I-7405, ECJ*), that there is a clear difference between the tests in Regulation 61(1) and 61(5). Regulation 61(1) says that an appropriate assessment must be made if the project *"is likely to have a significant effect on a European site"*, whereas Regulation 61(5), which refers to the results of an assessment uses the test *"that it will not adversely affect the integrity of the European site"*. [107-111]

150. In practical terms it makes little difference whether the assessment is carried out at the initial stage and concludes that no further appropriate assessment is required or if it is decided that appropriate assessment is required and then the assessment is carried out at that stage. It is a matter for the competent authority, in this case the

Welsh Ministers, to decide whether appropriate assessment is required or not. In my view, it would be prudent to rely on the well accepted conclusions of the *Waddenzee* judgement than to accept the questionable comparability and relevance of the *Champion* judgement. The *Waddenzee* judgement, in essence, provides guidance that the initial question to be considered under Regulation 61(1) is whether there is a "possibility" of having a significant effect on the SAC, whilst the subsequent appropriate assessment should then take into account any mitigation or control measures before reaching a conclusion under Regulation 61(5). This leads me to the conclusion that appropriate assessment is required.

151. It is common ground amongst the parties that, in this case, an appropriate assessment can be a relatively simple and straightforward process. It is agreed that the information needed is contained in the Applicants' helpful shadow appropriate assessment in the ESs, subject only to it making clearer reference to the key criterion that summer groundwater levels at the SAC should not change relative to normally expected levels by more than 0.1 m due to quarrying operations over 3 consecutive years. This measure has been taken into account in the shadow appropriate assessment but it is not explicitly stated. [50, 57, 112, 113]

152. The shadow appropriate assessment describes the qualifying interests of the Kenfig SAC, the concept of "favourable status", the features that might be affected by changes to the groundwater level regime, the appropriate measure for assessing whether or not they would be adversely affected, and the results of the hydrogeological modelling which indicates worst case changes in water levels due to quarrying activities. The shadow appropriate assessment then concludes that the quarrying would not have an adverse effect on the integrity of the SAC. [50-52, 56, 113]

153. I agree with that conclusion so far as normal circumstances are concerned. However, the shadow assessment makes inadequate provision for the possibility of encountering a highly permeable karstic feature, which could lead to high rates of water flow in that part of the aquifer, and it is considered that a more thorough assessment should include acknowledgement of that risk (albeit agreed by all parties as being very small) and recognition that measures now contained in the WMP and planning conditions will provide adequate identification, mitigation and contingency measures to ensure there would be no adverse effect on the SAC should that occur. The Appellants and NRW all advise that an appropriate assessment will be able to conclude that the proposed quarrying schemes will not adversely affect the integrity of the Kenfig SAC. I reach the same conclusion, though clearly it is the Welsh Ministers who are required to carry out the appropriate assessment as part of their decision making process. Of course, that assessment will be further informed by NRW in its capacity as "the appropriate nature conservation body" which Regulation 61(3) requires the decision maker to consult for purposes of the assessment. [55, 113]

154. For completeness, mention is also made of the Cefn Cribwr Grasslands SAC to the north of the quarries. All parties are agreed that there is no mechanism by which the quarry proposals could possibly have a significant effect on this SAC and that no further appropriate assessment is required for it. This is also described in the Applicants' shadow appropriate assessment in the ESs. [42, 114]

Blasting at Gaens Quarry

155. Finally, I turn to the matter of blasting at Gaens Quarry, which seems to have a history of events of concern to nearby residents. The Council has referred to a particular incident in 2009 when high levels of vibration were experienced at nearby sensitive properties despite subsequent investigations finding nothing obviously wrong with the design or implementation of the blast. That blasting was carried out about 125 metres away from the nearest properties, and work has been moved further away since that incident. Nevertheless, the quarry operator intends to return to that part of the quarry in due course, though probably not for another 25-30 years, and the Council maintains that improved measures are likely to be needed when that occurs. [72-74, 76, 87-89, 118, 120, 122]

156. The Council's initial approach was to prescribe a buffer zone to prevent quarry operations, or at least the use of blasting, in the part of the quarry closest to sensitive residential properties. However, that would sterilise the minerals within the buffer zone and conflict with the provisions in the 1995 Act to avoid imposing conditions that unreasonably prejudice the economic viability or asset value of the quarry. Restrictions of that sort should be the subject of a modification notice with consequent implications for compensation. Thus the parties have agreed an alternative approach. [75]

157. One of the conditions now proposed would require the quarry operator to carry out more detailed investigations of the geology in that part of the quarry in order to demonstrate the feasibility of blasting without generating levels of vibration in excess of the permitted standards. It would also required detailed design of the charges to be subject to approval by the Council. This is a reasonable approach and, in view of the problems experienced in the past, a necessary one. It is not intended to return to work that part of the quarry for another 25-30 years, during which time the quarry will have been subject to at least one and maybe 2 further periodic reviews of conditions. Nevertheless, I consider it appropriate to apply this condition now to provide the necessary assurance and certainty. [16, 76-78, 89, 90, 130]

Overall Conclusions

158. Several other matters have been raised by local residents, and it is important that appropriate controls are applied to address these various amenity matters. The proposed schedules of conditions include conditions aimed at making suitable provisions for these controls in line with latest good practice methods and procedures. I conclude that the proposed conditions would be reasonable in this respect. Furthermore, the conditions proposed for wider environmental protection and long-term restoration would meet modern standards, and I consider all of the conditions would meet the 6 tests prescribed for conditions in the Welsh Government Circular on planning conditions. In addition, none would invoke a need for formal notification of degradation of the operators' rights or the asset values. [15, 17, 18, 58-61, 63-67, 73, 81-83, 85, 86, 117, 119, 121, 124-129, 131, 132]

159. In reaching these conclusions I have taken into account the Environmental Statements (ESs) submitted in support of each application and all other environmental information submitted since. The latter has been adequately publicised through the public inquiry procedures. The Water Management Plans (WMPs) were included and

explained in the ESs. However, they were revised shortly before the inquiry to reflect improved arrangements for monitoring and mitigation measures (based on pathway monitoring), as agreed between the Applicants and NRW. These do not alter the fundamental nature of the WMPs, and it is not considered any interested party would be prejudiced by the changes. NRW, of course, are familiar with the changes. Accordingly, I do not consider any further public advertisement is necessary to meet the requirements of EIA legislation. [5-7]

Recommendations

160. Before determining these applications for approval of conditions, the Welsh Ministers have to consider whether or not appropriate assessment is required under the Habitats Regulations. I recommend that appropriate assessment be carried out.

Application A: Cornelly Quarry ROMP

161. I recommend that the schedule of conditions in Annex A of this report be approved.

Application B: Grove Quarry ROMP

162. I recommend that the schedule of conditions in Annex B of this report be approved.

Application C: Gaens Quarry ROMP

163. I recommend that the schedule of conditions in Annex C of this report be approved.

Application D: Cornelly and Gaens IDO Periodic Review

164. I recommend that the schedule of conditions in Annex D of this report be approved.

Clive Nield

Inspector

APPEARANCES

FOR THE LOCAL PLANNING AUTHORITY:

Ms Nicola Gandy, MSc, MRTPI	Principal Planning Officer, Development Control, Bridgend County Borough Council.
She gave evidence and called:	
Ms Helen Williams	Senior Environmental Health Officer, Public Protection, Bridgend CBC.

FOR NATURAL RESOURCES WALES:

Ms Sarah Sackman of Counsel	Instructed by Geldards LLP (Mr Charles Felgate, Partner).
She called:	
Dr Rob Low, BSc(Hon), MSc, CGeol, FGS	Director, Rigare Limited (Groundwater and Wetland Science Consultant).
Mr Kerry Rogers, BSc (Hon)	Ecologist, specialising in Habitats Regulations Assessment, NRW.

FOR APPLICANT, TARMAC:

Mr Richard Humphreys QC	Instructed by Nabarro LLP (Mr Christopher Bowes, Partner).
He called:	
Mr Michael Streetly, BA(Hon), MSc, CGeol, FGS	Director, ESI Limited (Water Resource Hydrogeology Consultant).
Mr Stuart Lowther, BA, MSc, CEnv, MCIEEM	Managing Director, Atmos Consulting Limited (Environmental Consultancy).
Mr Graham Jenkins, BA(Hon), MRTPI, MIQ	Technical Director, SLR Consulting Limited.

FOR APPLICANT, TS REES:

Mr Hugh Richards of Counsel	Instructed by TS Rees Ltd.
He called:	
Mr Will Ryan, BA(Hon), BTP, MRTPI	Technical Director, SLR Consulting Limited.

INTERESTED PERSONS:

Mr Peter Vincent	Local resident, representing South Cornelly Residents Association.
Mr Clive Tranter	Local resident.

DOCUMENTS

1 Letter of Notification and list of persons notified.

2 Schedule of Core Documents comprising:

- CD1.1-CD1.9: Guidance, Regulations and Policy;
- CD2.1-CD2.9: Cornelly Romp Application Documents, including Environmental Statement Volumes;
- CD3.1-CD3.9: Grove ROMP Application Documents, including Environmental Statement Volumes;
- CD4.1-CD4.9: Cornelly Grove IDO Periodic Review Application Documents, including Environmental Statement Volumes;
- CD5.1-CD5.8: Gaens ROMP Application Documents, including Environmental Statement Volumes;
- CD6.1-CD6.25: Other Documents.

3 Statement of Common Ground between Tarmac and Bridgend CBC in respect of Cornelly and Grove Applications, including Schedules of Proposed Planning Conditions.

4	Statement of Common Ground between TS Rees and Bridgend CBC in respect of Gaens Application.
5.1-5.2	Draft Statement of Common Ground between Tarmac and Natural Resources Wales, dated 14/9/15 with comments dated up to 1/10/15 (version 5.4): clean version and version with tracked changes.
6	Opening Statement on behalf of Tarmac Trading Ltd.
7	List of Appearances on behalf of Tarmac Trading Ltd.
8	Opening Statement on behalf of TS Rees Ltd.
9	Opening Statement on behalf of Natural Resources Wales.
10	Nicola Gandy's Statement of Evidence.
11.1-11.2	Helen Williams' Statement of Evidence with Appendices and Rebuttal Statement.
12.1-12.2	Rob Low's Proof of Evidence with Appendices and Rebuttal Proof of Evidence.
13.1-13.2	Kerry Rogers' Proof of Evidence with Appendices and Rebuttal Proof of Evidence.
14.1-14.7	Michael Streetly's Proof of Evidence, Summary of Proof of Evidence, Appendices A-C, Appendix D, Appendix E, Appendix F and Rebuttal Statement.
15.1-15.2	Stuart Lowther's Proof of Evidence (with Appendix) and Rebuttal Proof of Evidence.
16.1-16.5	Graham Jenkins' Proof of Evidence, Summary of Proof of Evidence, Appendices, Rebuttal Proof of Evidence re Dr Rob Low and Rebuttal Proof of Evidence re Graham Rogers.
17.1-17.3	Will Ryan's Proof of Evidence, Summary Proof of Evidence and Rebuttal Proof of Evidence.
18.1-18.2	Final Statements of Common Ground between Tarmac and NRW and between TS Rees and NRW, submitted at opening of Inquiry.
19.1-19.6	Water Management Plans for Cornelly, Grove and Gaens Quarries, v5.8 dated 9 November 2015: clean versions and versions with tracked changes, submitted at opening of Inquiry.
20	Additional conditions suggested by Bridgend CBC concerning blasting at Gaens Quarry.

21	Sketches of relationships between water table variations and zone of ecological interest, submitted by NRW (Mr Rogers).
22	Technical Note on Anticipated Responses at Pathways, submitted by Tarmac (Mr Streetly).
23	Peter Vincent's statement of evidence and attachments.
24	Letter submitted by Mr & Mrs D Nicholas, local residents.
25	Copy of letter from SLR to PINS, dated 24 September 2015, concerning advertisement of revised Water Management Plans, submitted by Tarmac.
26.1-26.6	Updated Schedules of Planning Conditions for Cornelly and Grove Quarries ROMPs and Cornelly/Grove Quarries IDO Review (plain and tracked versions for each), reflecting discussion on conditions held during Inquiry, submitted by Tarmac at close of Inquiry.
27	Updated Schedule of Planning Conditions for Gaens Quarry ROMP, reflecting discussion on conditions held during Inquiry, submitted by TS Rees at close of Inquiry.
28	Closing Statement on behalf of Bridgend CBC.
29	Closing Statement on behalf of Natural Resources Wales.
30	Closing Statement on behalf of TS Rees Ltd.
31	Closing Statement on behalf of Tarmac Trading Ltd.
32.1-32.2	Judgements referred to by parties in Closing Submissions: Court of Appeal judgement on R (on the application of Champion) v North Norfolk DC *[2013] EWCA Civ 1657 and [2014] Env. L.R. 23*; and Supreme Court judgement on same *[2015] UKSC 52*.
33.1-33.3	Plans of Kenfig Dunes used for site visit.
34.1-34.2	Aerial photographs of Cornelly Quarry used for site visit.

ANNEX A - CORNELLY QUARRY ROMP (REF: 516086)

RECOMMENDED SCHEDULE OF PLANNING CONDITIONS

A: DEFINITION OF TERMS

For the purposes of these planning conditions the following words and phrases shall have the meaning given to them below:

i. "ROMP Area" means the area subject to the application submitted to Bridgend County Borough Council under the provisions of Schedule 13 of the Environment Act 1995 for a Review of the planning conditions regulating quarrying operations at Cornelly Quarry (ref P/97/623), shown outlined in red on Plan 1 accompanying the schedule of planning conditions.

ii. "ROMP Application" means the application submitted to Bridgend County Borough Council under the provisions of Schedule 13 of the Environment Act 1995 for a Review of the planning conditions regulating quarrying operations at Cornelly Quarry (ref P/97/623).

iii. "IDO Area" means the eastern area of the IDO permission ref 53/93/1350 which is the subject of a separate application submitted to Bridgend County Borough Council under the provisions of Schedule 14 of the Environment Act 1995 for a Review of the planning conditions regulating quarrying operations within the IDO area of Cornelly and Grove Quarries (ref P/09/738/MIN) shown coloured pink on Plan 1 accompanying the schedule of planning conditions.

iv. "Date of Determination" means the date upon which new conditions subsequent to the applications are finally determined, i.e. the date upon which all proceedings on the applications, including appeals to the Secretary of State and the High Court have been determined, and the time period for any further appeal has expired.

v. "Emergency" means any circumstances in which the operator has a reasonable cause for apprehending injury to persons or serious damage to property.

vi. "Mineral Planning Authority, (MPA)", means Bridgend County Borough Council, or any successor mineral planning authority.

vii. "The Site", means all that land at Cornelly Quarry which is currently within the permitted area of Cornelly Quarry, comprising the "ROMP Area" of Cornelly and Pant Mawr Quarries, shown outlined in red on Plan 1 accompanying the schedule of planning conditions, and the eastern part of the IDO area shown coloured pink on Plan 1 accompanying the schedule of planning conditions.

viii. "2014 ES" means the Environmental Statement (ES) submitted in June 2014 in support of the Cornelly Quarry ROMP application.

ix. "Quarrying operations" means the winning and working of stone from the quarry face, and the operation of the primary crusher/or other mechanical means of stone breaking.

x. "Temporary operations" means operations associated with soil and overburden stripping, construction of soil storage mounds, construction of site haul roads, construction of soil baffle mounds, and restoration works involving the use of machinery. Temporary operations are to be confined to a period of no more than 8 weeks in a calendar year.

B TIME LIMITS

1. This planning permission shall expire on 31st December 2056.
2. Following the expiry of the planning permission, all extraction, treatment, and stockpiling of minerals shall cease.
3. No later than 12 months following the expiry of the planning permission, or the earlier permanent cessation of winning and working of minerals, all plant, machinery and structures shall be dismantled and removed from the site.
4. No later than 12 months following the expiry of the planning permission, or the earlier permanent cessation of winning and working of minerals, as agreed by both the mineral operator and MPA, the sale and transportation of minerals to and from the site, together with all ancillary manufacturing activities shall cease.

C WORKING PROGRAMME

5. The winning and working of stone and disposal of overburden/quarry waste shall be carried out in accordance with the updated quarry development plan ref numbers C112/097- C112/105 inclusive.
6. The site access shall be surfaced in permanent materials, and the surface maintained in a good state of repair, and kept free of mud/debris at all times.

7. Except in the case of emergency, quarrying operations shall take place only between the hours of 06:00-22:00 Mondays to Saturdays, and at no time on Sundays or Bank Holidays, except for essential maintenance.

   (NB: (i) *For the purpose of this condition, quarrying operations shall be defined as winning and working of stone from the quarry face, and the operation of the primary crusher/or other mechanical means of stone breaking.*

   (ii) *All other items of plant including secondary crushers, screens, sinter mills, asphalt plant, and concrete plant, lie within the 'IDO' area where the hours of working are unrestricted*.)

8. Within the working hours specified in Condition 7, there shall be no drilling operations, or secondary breakage of stone between the hours of 06:00 – 07:00 and 19:00-22:00 hours.

9. Temporary operations, as defined in Section A, shall only be carried out between 08:00 – 19:00 hours Mondays to Fridays.

10. No operations associated with the formation of the Western Pant Mawr Tip illustrated on plans ref C112.102 and C112.104, and formation and subsequent removal of material from bunds/soil storage areas shall be carried out at the site except between the hours of 08:00 – 17:00 Mondays to Fridays, and 08:00 -13:00 on Saturdays.

D ENVIRONMENTAL PROTECTION

Hydrology and Hydrogeology

11. The water management, monitoring, reporting, mitigation and contingency activities set out in the Water Management Plan (WMP) for Cornelly Quarry v5.8 dated 9th November 2015 shall be carried out throughout the life of the development.

12. In the event that the Minerals Planning Authority requires changes to the WMP, as provided for in the WMP, then the amended water management, monitoring, reporting, mitigation and contingency activities requested by the Minerals Planning Authority shall be carried out for the remaining life of the development.

13. Prior to the cessation of dewatering, a scheme shall be submitted to and approved in writing by the Minerals Planning Authority setting out proposals for residual pumping during the quarry decommissioning stage. The scheme shall include details of the rates and timescale of residual pumping, and the measures to be taken to monitor the effectiveness of the residual pumping during the defined time period. The scheme shall thereafter be implemented in accordance with the approved scheme.

14. Any facilities for storage of oils, fuels or chemicals on the site shall be sited in impervious bases and surrounded by impervious bund walls. The volume of the bunded compound shall be at least equivalent to the capacity of the tank plus 10%. If there is multiple tankage, the compound shall be at least equivalent to the capacity of the largest tank, or the combined capacity of inter-connective tanks, plus 10%. All filling points, vents, gauges and site glasses shall be located within the bund. The drainage system of the bund shall be sealed with no discharge to any water course, land or underground strata. Associated pipe-work shall be located above ground and protected from accidental damage.

15. To minimise the risk of groundwater pollution from quarrying and processing operations, the development shall be carried out in accordance with the following requirements:

- All mobile plant which requires fuel for its operation should be located on hard standing when not in use.
- All immobile plant which requires fuel for its operation should be located on hard standing. Drip trays should also be appropriately placed under all relevant plant.
- All refuelling activities should be undertaken on areas of hard standing, taking appropriate care and attention.
- An incident reporting procedure should be maintained for reporting all site incidents, including pollution events. Emergency responses should be in place in the event of an incident.
- Appropriate spill kits or other means of controlling accidental spills should be made available on site. Adequate training in the use of such equipment should also be provided.
- A maintenance and inspection programme should be followed in order to check the condition of site equipment and provide early warning of any potential leaks or spills.
- Suitable waste management procedures should be followed to prevent surface pollution resulting from any waste products, fuel containers, and chemical drums.
- During site restoration all hazardous plant and equipment should be removed from the quarry.
- The use of herbicides and other related chemicals should be restricted both during quarry working and post restoration. Chemical applications should be made at appropriate times, in suitable quantities, so as to avoid sub surface contamination.

Ecology

16. Within 6 months of the date of determination, an Ecological Mitigation Strategy (EMS) shall be submitted to the MPA for their approval in writing. The EMS shall include the mitigation measures set out in Section 8.7 of the 2014 ES. The EMS shall thereafter be implemented as approved.

17. In addition to the measures to be included in the EMS, in order to minimise disturbance of habitats and interference with species, the development shall be carried out in accordance with the following requirements:

    (i) Calcareous grasslands on the fringes of Cornelly and Pant Mawr Quarries, which would be unaffected by the development scheme, shall be fenced to prevent accidental incursion of vehicles and site personnel;

    (ii) Areas of inaccessible high cliff shall be identified each year, and, subject to operational requirements shall be left undisturbed in order to encourage potential habitat for nesting peregrine falcons;

    (iii) Any large trees or large crevices in undisturbed parts of the quarry shall be inspected for possible bat presence immediately ahead of any tree surgery or quarrying works. Any bats which are identified shall be dealt with in accordance with current legislation and best practice;

    (iv) Clearance of trees and scrub should avoid the main bird nesting season (March to August inclusive);

    (v) Common reptiles encountered during works should be allowed to leave the immediate works area unharmed, and, if necessary, should be assisted by means of capture and release;

    (vi) Dense ruderal and grassland vegetation should be strimmed and raked away at least 24 hours ahead of earthworking, so as to reduce the attractiveness of the area for reptiles, and encourage them to leave;

    (vii) Written protocols shall be issued to contractors so that in the event of discovery of bats, nesting birds, badgers or common reptiles, compliance with statutory obligations is ensured.

Landscaping

18. Within 6 months of the date of determination a scheme shall be submitted to the MPA for their approval in writing setting out proposals for the beating up and infilling of the existing hedgerow alongside the southern boundary of the ROMP area and IDO area abutting Mount Pleasant Road. The scheme shall include proposals for the timescale for implementation of the works, which shall thereafter be implemented in accordance with the approved scheme.

19. Within 6 months of the date of determination a scheme shall be submitted to the MPA for their approval in writing setting out proposals for the construction of a 2.0m high screening bund along the southern boundary of the IDO area of Grove Quarry, abutting Mount Pleasant Road. The scheme should include provision for the bund to be constructed with an outer gradient of no steeper than 1:2 (v/h) and grass seeded and planted with native trees and shrubs to provide a vegetated visual barrier to views. The scheme shall include proposals for the timescale for implementation of the works, which shall thereafter be implemented in accordance with the approved scheme.

20. Within 6 months of the date of determination a scheme shall be submitted to the MPA for their approval in writing setting out proposals for the infilling, widening and strengthening of the hedgerow/woodland belt along the northern boundary of the quarry void. The scheme shall include proposals for the timescale for implementation of the works, which shall thereafter be implemented in accordance with the approved scheme.

21. Within 6 months of the date of determination a scheme shall be submitted to the MPA for their approval in writing setting out proposals for the intermediate restoration of the upper faces/benches illustrated on plan ref numbers C112/097- C112/105. The restoration works shall thereafter be implemented in accordance with the approved scheme.

22. Prior to the commencement of construction of the Pant Mawr Quarry Western Tip, shown on plan ref numbers C112.102 and C112.104, a scheme shall be submitted to the MPA for their approval in writing setting out proposals for the landscape treatment of the finished profiles of the tip. The scheme shall include details of grass seeding, tree and shrub planting schedules, and proposals for maintenance of the restored tip area. Any trees, shrubs or hedges which die, are removed or become seriously damaged or diseased within 5 years of planting, shall be replaced in the next planting season with others of a similar size and species, unless otherwise agreed in writing by the MPA. The scheme shall thereafter be implemented in accordance with the approved scheme.

Noise

23. Except for temporary operations, the free-field Equivalent Continuous Noise Level, $L_{Aeq,1\ hour}$ due to operations in the site, shall not exceed the relevant criterion limit specified in Schedule 1 at each nominated dwelling for the periods specified. Measurements taken to verify compliance shall have regard to the effects of extraneous noise and shall be corrected for any such effects.

Schedule 1 Noise Criteria Limits

Location	**07:00-19:00** **Criterion** dB $L_{Aeq,\ T}$	**06:00-07-00** **Criterion** dB $L_{Aeq,\ T}$	**19:00-22:00** **Criterion** dB $L_{Aeq,\ T}$	**22:00-06:00** **Criterion** dB $L_{Aeq,\ T}$
Rock Cottages in South Cornelly	50	42	48	42
Danygraig (Holiday Caravan Camp)	55	45	48	42
Grove Farm House, Grove	55	45	48	42
Sea View, Mount Pleasant Road	50	45	48	42
Manderlay, Stormy Down	55	48	48	42
Ballas Farm	55	48	48	42
Ty Tanglwyst Farm	55	48	48	42
Mount Pleasant Farm	53	45	48	42

24. For temporary operations such as site preparation, soil and overburden stripping, bund formation and removal and final restoration, the free-field noise level due to work at the nearest point to each dwelling shall not exceed 67 dB $L_{Aeq,\ 1\ hour}$. Temporary operations shall not exceed a total of eight weeks in any calendar year for work close to any individual noise sensitive property.

Blasting

25. Except with the written consent of the MPA, or in the case of emergency, blasting operations shall be carried out only between 1000 and 1700 hours Monday to Friday, and only in exceptional circumstances on Saturday and not at all on Sunday and Public/Bank Holidays.

26. Ground vibration as a result of blasting shall not exceed a peak particle velocity of $6mms^{-1}$ in 95% of all blasts measured over any six month period, and no individual blast shall exceed a peak particle velocity of $10mms^{-1}$ measured at any vibration sensitive location, which is defined as any residential property in the vicinity of the quarry existing at the Date of Determination. The measurements shall be the maximum of three perpendicular directions taken at the ground surface.

27. All individual blasts shall be designed, managed and implemented to minimise the extent of air overpressure resulting from blasts, having regard to blast design, methods of initiation of blasts, and also as far as practicable to weather conditions prevailing at the time of initiation.

28. Each individual blast shall be monitored by the Operators, to include: provision for recording the details and location of the monitoring station; the location of the blast holes within the Site; weather conditions; specification of the blast in terms of MIC; and total charge weight. Blast monitoring is to be undertaken at the closest sensitive receptor to the blast location or at an alternative location that is requested by the Mineral Planning Authority. Records of blast monitoring shall be made available to the MPA upon request. Any complaints which are received shall be logged against each particular blast. In the event that monitoring indicates that the vibration levels set out in condition 26 above have been exceeded, then the Operator shall inform the MPA within two working days, with written confirmation of the steps to be taken to ensure compliance with condition 26.

29. Blasting times shall be clearly advertised at the Quarry site entrance, and an audible warning shall be sounded prior to any blasting operations taking place, and shall be sounded again immediately after blasting has finished.

30. There shall be no secondary breakage of stone by the use of explosives.

Dust

31. At all times during the carrying out of operations, a water bowser or similar equipment shall be available on site, and be used to minimise the emission of dust from haul roads and access roads within the site, and the processing plant site hard-standings..

32. Measures shall be taken to minimise dust emissions from quarrying operations, in accordance with the following protocol:

    - Soils and overburden shall not be handled during extreme dry conditions unless the working areas are first dampened down.
    - Drilling of shot holes shall be undertaken using drilling rigs fitted with a suitable dust collection system.
    - Site roads within the quarry shall be dampened down as appropriate, in accordance with the requirement of condition 31.
    - The site entrance road shall be maintained by use of a road sweeper which shall operate as required to maintain the surface of the road free of mud and other detritus.
    - All lorries, once loaded, shall be sheeted prior to leaving the site, with the exception of any load carrying only plus 75mm size diameter stone.
    - The speed of haulage vehicles at the site will be restricted to 10mph.
    - All site vehicles will be fitted with upswept exhausts and radiator fan shields.
    - Lorries will be loaded so as to avoid spillages.
    - All site traffic will be kept to the designated haul routes
    - Any plant spillages will be cleared to avoid accumulations.
    - Drop heights will be minimised at loading and discharge points.

Restoration

33 The development shall proceed in accordance with the concept restoration plan ref numbers C112/106 - C112/108 and the details of interim and final restoration treatments, landscaping, and aftercare, set out in Chapter 4.0 of the 2014 ES.

34. Not later than 31st December 2054, or the expiry of six months following the permanent cessation of the winning and working of minerals, whichever is the sooner, the Operator shall submit for the written approval of the MPA, a detailed final restoration scheme, including drawings to illustrate the proposals for the final restoration of the quarry. The final restoration scheme shall be based upon the concept restoration plan ref numbers C112/106 - C112/108, and provide for the site to be restored as a nature conservation bias, with restoration treatment of the benches and faces above the water level which will be formed in the void. The scheme shall include updated predictions of the final rest water level of the lake. The remainder of the site shall be cleared of all plant, machinery, buildings and structures in accordance with the requirements of Condition 3. The restoration scheme shall include details of the final re-profiling works for the site, the soil /soil forming material profiles to be established; tree and shrub planting schedules; seeding, fencing and drainage; and a programme and timetable for the implementation of the works.

35 Not later than 31st December 2054, or the expiry of six months following the permanent cessation of the winning and working of minerals, whichever is the sooner, the Operator shall submit for the written approval of the MPA, a detailed aftercare management plan. The management plan shall be in substantial accordance with the details of the final restoration scheme and the principles of the strategic aftercare management strategy set out in Chapter 4.0 of the 2014 ES.

ANNEX B - GROVE QUARRY ROMP (REF: 516087)

RECOMMENDED SCHEDULE OF PLANNING CONDITIONS

A: DEFINITION OF TERMS

For the purposes of these planning conditions the following words and phrases shall have the meaning given to them below:

i. "ROMP Area" means the area subject to the application submitted to Bridgend County Borough Council under the provisions of Schedule 13 of the Environment Act 1995 for a Review of the planning conditions regulating quarrying operations at Grove Quarry (ref P/97/618), shown outlined in purple on Plan 1 accompanying the schedule of conditions.

ii. "ROMP Application" means the application submitted to Bridgend County Borough Council under the provisions of Schedule 13 of the Environment Act 1995 for a Review of the planning conditions regulating quarrying operations at Cornelly Quarry (ref P/97/618).

iii. "IDO Area" means the western area of the IDO permission ref 53/93/1350 which is the subject of a separate application submitted to Bridgend County Borough Council under the provisions of Schedule 14 of the Environment Act 1995 for a Review of the planning conditions regulating quarrying operations within the IDO area of Cornelly and Grove Quarries (ref P/09/738/MIN), shown coloured yellow on Plan 1 accompanying the schedule of conditions.

iv. "Date of Determination" means the date upon which new conditions subsequent to the applications are finally determined, i.e. the date upon which all proceedings on the applications, including appeals to the Secretary of State and the High Court have been determined, and the time period for any further appeal has expired.

v. "Emergency" means any circumstances in which the operator has a reasonable cause for apprehending injury to persons or serious damage to property.

vi. "Mineral Planning Authority, (MPA)", means Bridgend County Borough Council, or any successor mineral planning authority.

vii. "The Site", means all that land at Grove Quarry which is currently within the permitted area of Grove Quarry, comprising the "ROMP Area" shown outlined in purple on Plan 1 accompanying the schedule of conditions and the western part of the IDO area shown coloured yellow on Plan 1 accompanying the schedule of conditions.

viii "2014 ES" means the Environmental Statement (ES) submitted in June 2014 in support of the Grove Quarry ROMP application.

ix. "Temporary operations" means operations associated with soil and overburden stripping, construction of soil storage mounds, construction of site haul roads, construction of soil baffle mounds, and restoration works involving the use of machinery. Temporary operations are to be confined to a period of no more than 8 weeks in a calendar year.

A TIME LIMITS

1. The MPA shall be given 7 days notice in writing prior to a resumption of quarrying operations at Grove Quarry.

2. This planning permission shall expire on 31st December 2056.

3. Following the expiry of the planning permission, all extraction, treatment, and stockpiling of minerals shall cease.

4. No later than 12 months following the expiry of the planning permissions, or the earlier permanent cessation of winning and working of minerals, all plant, machinery and structures shall be dismantled and removed from the site.

5. No later than 12 months following the expiry of the planning permission, or the earlier permanent cessation of winning and working of minerals, as agreed by both the mineral operator and MPA, the sale and transportation of minerals to and from the site, together with all ancillary manufacturing activities shall cease.

B WORKING PROGRAMME

6. The winning and working of stone and disposal of overburden/quarry waste shall be carried out in accordance with the updated quarry development plan ref numbers G057/016 to G057/019.

7. The site access shall be surfaced in permanent materials, and the surface maintained in a good state of repair, and kept free of mud/debris at all times.

8. The winning and working of stone from the quarry faces, and operation of a primary crusher, shall take place only between the hours of 07:00 - 19.00 Mondays to Fridays and 07.00 – 13.00 on Saturdays, and at no time on Sundays or Bank Holidays, except for essential maintenance or otherwise agreed in writing by the MPA.

9. Temporary operations, as defined in Section A, shall only be carried out between 08:00 – 19:00 hours Mondays to Fridays.

C ENVIRONMENTAL PROTECTION

Hydrology and Hydrogeology

10. The water management, monitoring, reporting, mitigation and contingency activities set out in the Water Management Plan (WMP) for Grove Quarry v5.8 dated 9th November 2015 shall be carried out throughout the life of the development.

11. In the event that the Minerals Planning Authority requires changes to the WMP, as provided for in the WMP, then the amended water management, monitoring, reporting, mitigation and contingency activities requested by the Minerals Planning Authority shall be carried out for the remaining life of the development.

12. Prior to the cessation of dewatering, a scheme shall be submitted to and approved in writing by the Minerals Planning Authority setting out proposals for residual pumping during the quarry decommissioning stage. The scheme shall include details of the rates and timescale of residual pumping, and the measures to be taken to monitor the effectiveness of the residual pumping during the defined time period. The scheme shall thereafter be implemented in accordance with the approved scheme.

13. Any facilities for storage of oils, fuels or chemicals on the site shall be sited in impervious bases and surrounded by impervious bund walls. The volume of the bunded compound shall be at least equivalent to the capacity of the tank plus 10%. If there is multiple tankage, the compound shall be at least equivalent to the capacity of the largest tank, or the combined capacity of inter-connective tanks, plus 10%. All filling points, vents, gauges and site glasses shall be located within the bund. The drainage system of the bund shall be sealed with no discharge to any water course, land or underground strata. Associated pipe-work shall be located above ground and protected from accidental damage.

14. To minimise the risk of groundwater pollution from quarrying and processing operations, the development shall be carried out in accordance with the following requirements**:**

    - All mobile plant which requires fuel for its operation should be located on hard standing when not in use.

- All immobile plant which requires fuel for its operation should be located on hard standing. Drip trays should also be appropriately placed under all relevant plant.
- All refuelling activities should be undertaken on areas of hard standing, taking using appropriate care and attention.
- An incident reporting procedure should be maintained for reporting all site incidents, including pollution events. Emergency responses should also be in place in the event of an incident.
- Appropriate spill kits or other means of controlling accidental spills should be made available on site. Adequate training in the use of such equipment should also be provided.
- A maintenance and inspection programme should be followed in order to check the condition of site equipment and provide early warning of any potential leaks or spills.
- Suitable waste management procedures should be followed to prevent surface pollution resulting from any waste products, fuel containers, and chemical drums.
- During site restoration all hazardous plant and equipment should be removed from the quarry.
- The use of herbicides and other related chemicals should be restricted both during quarry working and post restoration. Chemical applications should be made at appropriate times, in suitable quantities, so as to avoid sub surface contamination.

Ecology

15. Within 6 months of the date of determination, an Ecological Mitigation Strategy (EMS) shall be submitted to the MPA for their approval in writing. The EMS shall include the mitigation measures set out in Section 8.7 of the 2014 ES. The EMS shall thereafter be implemented as approved.

16. In addition to the measures to be included in the EMS, in order to minimise disturbance of habitats and interference with species, the development shall be carried out in accordance with the following requirements:

    (i) Areas of inaccessible high cliff shall be identified each year, and, subject to operational requirements shall be left undisturbed in order to encourage potential habitat for nesting peregrine falcons;

(ii) Any large trees or large crevices in undisturbed parts of the quarry shall be inspected for possible bat presence immediately ahead of any tree surgery or quarrying works. Any bats which are identified shall be dealt with in accordance with current legislation and best practice;

(iii) Clearance of trees and scrub should avoid the main bird nesting season (March to August inclusive);

(iv) Common reptiles encountered during works should be allowed to leave the immediate works area unharmed, and, if necessary, should be assisted by means of capture and release;

(v) Dense ruderal and grassland vegetation should be strimmed and raked away at least 24 hours ahead of earthworking, so as to reduce the attractiveness of the area for reptiles, and encourage them to leave;

(vi) Written protocols shall be issued to contractors so that in the event of discovery of bats, nesting birds, badgers or common reptiles, compliance with statutory obligations is ensured.

Landscaping

17. The limits of quarrying within the ROMP area shall be confined to the areas illustrated on plan ref numbers G057/016 to G057/019. No quarrying operations shall take place within the woodland area along the western side of the ROMP area beyond the defined limit of quarrying.

18 Within 6 months of the date of determination a scheme shall be submitted to the MPA for their approval in writing setting out proposals for the beating up and infilling the existing hedgerow alongside the southern boundary of the IDO area abutting Mount Pleasant Road. The scheme shall include proposals for the timescale for implementation of the works, which shall thereafter be implemented in accordance with the approved scheme.

19. Within 6 months of the date of determination a scheme shall be submitted to the MPA for their approval in writing setting out proposals for the construction of a 2.0m high screening bund along the southern boundary of the IDO area of Grove Quarry, abutting Mount Pleasant Road. The scheme should include provision for the bund to be constructed with an outer gradient of no steeper than 1:2 (v/h) and grass seeded and planted with native trees and shrubs to provide a vegetated visual barrier to views. The scheme shall include proposals for the timescale for implementation of the works, which shall thereafter be implemented in accordance with the approved scheme.

20. Within 6 months of the date of determination a scheme shall be submitted to the MPA for their approval in writing setting out proposals for the infilling and strengthening of the woodland belt along the lower sections of the wooded northern flank of the IDO area along the Heol y Splot corridor. The scheme shall include proposals for the timescale for implementation of the works, which shall thereafter be implemented in accordance with the approved scheme.

21. Prior to the commencement of operations in Phase b (plan ref G057/017) a scheme shall be submitted to the MPA for their approval in writing setting out proposals for the intermediate restoration of the upper faces/benches illustrated on plan ref numbers G057/016 to G057/019. The restoration works shall thereafter be implemented in accordance with the approved scheme.

Noise

22. Except for temporary operations, the free-field Equivalent Continuous Noise Level, $L_{Aeq,1\ hour}$ due to operations in the site, shall not exceed the relevant criterion limit specified in Schedule 1 at each nominated dwelling for the periods specified. Measurements taken to verify compliance shall have regard to the effects of extraneous noise and shall be corrected for any such effects.

Schedule 1 Noise Criteria Limits

Location	**07:00-19:00** **Criterion** dB $L_{Aeq,\ T}$
Rock Cottages in South Cornelly	55
Danygraig (Holiday Caravan Camp)	55
Grove Farm House, Grove	55
Sea View, Mount Pleasant Road	55
Manderlay, Stormy Down	55
Ballas Farm	55
Ty Tanglwyst Farm	55
Mount Pleasant Farm	53

23. For temporary operations such as site preparation, soil and overburden stripping, bund formation and removal and final restoration, the free-field noise level due to work at the nearest point to each dwelling shall not exceed 67 dB $L_{Aeq,\ 1\ hour}$. Temporary operations shall not exceed a total of eight weeks in any calendar year for work close to any individual noise sensitive properties.

Blasting

24. Except with the written consent of the MPA, or in the case of emergency, blasting operations shall be carried out only between 1000 and 1700 hours Monday to Friday, and only in exceptional circumstances on Saturday and not at all on Sunday and Public/Bank Holidays.

25. Ground vibration as a result of blasting shall not exceed a peak particle velocity of $6mms^{-1}$ in 95% of all blasts measured over any six month period, and no individual blast shall exceed a peak particle velocity of $10mms^{-1}$ measured at any vibration sensitive location, which is defined as any residential property in the vicinity of the quarry existing at the Date of Determination. The measurements shall be the maximum of three perpendicular directions taken at the ground surface.

26. All individual blasts shall be designed, managed and implemented to minimise the extent of air overpressure resulting from blasts having regard to blast design, methods of initiation of blasts, and also as far as practicable to weather conditions prevailing at the time of initiation.

27. Each individual blast shall be monitored by the Operators, to include: provision for recording the details and location of the monitoring station; the location of the blast holes within the Site; weather conditions; specification of the blast in terms of MIC; and total charge weight. Blast monitoring is to be undertaken at the closest sensitive receptor to the blast location or at an alternative location that is requested by the Mineral Planning Authority. Records of blast monitoring shall be made available to the MPA upon request. Any complaints which are received shall be logged against each particular blast. In the event that monitoring indicates that the vibration levels set out in condition 25 above have been exceeded, then the Operator shall inform the MPA within two working days, with written confirmation of the steps to be taken to ensure compliance with condition 25.

28. Blasting times shall be clearly advertised at the Quarry site entrance, and an audible warning shall be sounded prior to any blasting operations taking place, and shall be sounded again immediately after blasting has finished.

29. There shall be no secondary breakage of stone by the use of explosives.

Dust

30. At all times during the carrying out of operations, a water bowser or similar equipment shall be available on site, and be used to minimise the emission of dust from haul roads and access roads within the site, and the processing plant site hard-standings.

31. Measures shall be taken to minimise dust emissions from quarrying operations, in accordance with the following protocol:

    - Soils and overburden shall not be handled during extreme dry conditions unless the working areas are first dampened down;
    - Drilling of shot holes shall be undertaken using drilling rigs fitted with a suitable dust collection system;
    - Site roads within the quarry shall be dampened down as appropriate, in accordance with the requirement of conditions 30;
    - The site entrance road shall be maintained by use of a road sweeper which shall operate as required to maintain the surface of the road free of mud and other detritus.
    - All lorries, once loaded, shall be sheeted prior to leaving the site, with the exception of any load carrying only plus 75mm diameter size stone.
    - The speed of haulage vehicles at the site will be restricted to 10mph.
    - All site vehicles will be fitted with upswept exhausts and radiator fan shields.
    - Lorries will be loaded so as to avoid spillages.
    - All site traffic will be kept to the designated haul routes
    - Any plant spillages will be cleared to avoid accumulations.
    - Drop heights will be minimised at loading and discharge points.

Restoration

32. The development shall proceed in accordance with the concept restoration plan ref numbers G057/020 - G057/021 and the details of interim and final restoration treatments, landscaping, and aftercare, set out in Chapter 4.0 of the 2014 ES.

33. Not later than 31st December 2054, or the expiry of six months following the permanent cessation of the winning and working of minerals, whichever is the sooner, the Operator shall submit for the written approval of the MPA, a detailed final restoration scheme, including drawings to illustrate the proposals for the final restoration of the quarry. The final restoration scheme shall be based upon the concept restoration plan ref numbers G057/020 - G057/021, and provide for the site to be restored as a nature conservation bias, with restoration treatment of the benches and faces above the water level which will be formed in the void. The scheme shall include updated predictions of the final rest water level of the lake. The remainder of the site shall be cleared of all plant, machinery, buildings and structures in accordance with the requirements of condition 4. The restoration scheme shall include details of the final re-profiling works for the site, the soil /soil forming material profiles to be established; tree and shrub planting schedules; seeding, fencing and drainage; and a programme and timetable for the implementation of the works.

34. Not later than 31st December 2054, or the expiry of six months following the permanent cessation of the winning and working of minerals, whichever is the sooner, the Operator shall submit for the written approval of the MPA, a detailed aftercare management plan. The management plan shall be in substantial accordance with the details of the final restoration scheme and the principles of the strategic aftercare management strategy set out in Chapter 4.0 of the 2014 ES.

ANNEX C - GAENS QUARRY ROMP (REF: 516088)

RECOMMENDED SCHEDULE OF PLANNING CONDITIONS

A: Definition of Terms

For the purposes of these planning conditions the following words and phrases shall have the meaning given to them below:

i. "ROMP Area" means the area subject to the application submitted to Bridgend County Borough Council under the provisions of Schedule 13 of the Environment Act 1995 for a Review of the planning conditions regulating quarrying operations at Gaens Quarry;

ii. "ROMP Application" means the application submitted to Bridgend County Borough Council under the provisions of Schedule 13 of the Environment Act 1995 for a Review of the planning conditions regulating quarrying operations at Gaens Quarry;

iii "Date of Determination" means the date upon which new conditions subsequent to the applications are finally determined, i.e. the date upon which all proceedings on the applications, including appeals to the Secretary of State and the High Court have been determined, and the time period for any further appeal has expired;

iii. "Emergency" means any circumstances in which the operator has a reasonable cause for apprehending injury to persons or serious damage to property;

iv. "Mineral Planning Authority, (MPA)", means Bridgend County Borough Council, or any successor mineral planning authority;

v. "The Site", means all that land at Gaens Quarry which is currently within the permitted area of Gaens Quarry, comprising the "ROMP Area"; and

vi. "2014 ES" means the Environmental Statement (ES) submitted in June 2014 in support of the Gaens Quarry ROMP application.

B: Time Limits

Duration

1. The planning permission hereby granted shall expire on the 6th January 2068.

2. On the expiry of the planning permission, all extraction, processing and stockpiling of minerals shall cease and not recommence.

3. No later than 12 months following the expiry of the planning permissions, or the earlier permanent cessation of winning and working of minerals, all plant, machinery and structures shall be dismantled and removed from the site.

4. No later than 12 months following the expiry of the planning permission, or the earlier permanent cessation of winning and working of minerals, the sale and transportation of minerals to and from the site, together with all ancillary manufacturing activities shall cease.

C: Working Programme

5. The winning and working of stone shall be carried out in accordance with the updated quarry development plan ref numbers 3782/02 to 3782/05 inclusive.

6. The sole means of vehicular access to and from the site shall be from Porthcawl Road as defined on Plan Ref. No. 3782/01: Existing Layout.

7. The site access shall be surfaced in permanent materials, and the surface maintained in a good state of repair, and kept free of mud/debris at all times.

8. Except in emergencies to maintain safe quarry working the following shall apply:

    a. No quarry operations, other than water pumping, the servicing/maintenance of plant, and environmental monitoring, shall be carried out at the site except between the following times:

        i. 0600 – 2200 hours Monday to Friday; and
        ii. 0600 – 1600 hours Saturday;

    b. No operations other than environmental monitoring and water pumping at the site shall take place on Sundays or public/bank holidays.

    c. No operations for the formation and subsequent removal of material from bunds/soil storage areas shall be carried out at the site except between the following times:

        i. 0800 – 1800 hours Monday to Friday; and
        ii. 0800 – 1300 hours on Saturdays.

    d. Deliveries and collection of aggregates shall only be made between the following times:

       0700 – 1900 hours Monday to Friday
       0700 – 1300 hours Saturday with no deliveries/collections on Sundays or Public /Bank Holidays

e. Within the working hours specified above, temporary operations shall only be carried out between 0800 - 1900 hours Monday to Fridays.

D: Environmental Protection

Hydrology & Hydrogeology

9. The water management, monitoring, reporting, mitigation and contingency activities set out in the Water Management Plan (WMP) for Gaens Quarry v5.8 dated 9th November 2015 shall be carried out throughout the life of the development.

10. In the event that the Minerals Planning Authority requires changes to the WMP, as provided for in the WMP, then the amended water management, monitoring, reporting, mitigation and contingency activities requested by the Minerals Planning Authority shall be carried out for the remaining life of the development.

11. Prior to the cessation of dewatering, a scheme shall be submitted to and approved in writing by the Minerals Planning Authority setting out proposals for residual pumping during the quarry decommissioning stage. The scheme shall include details of the rates and timescale of residual pumping, and the measures to be taken to monitor the effectiveness of the residual pumping during the defined time period. The scheme shall thereafter be implemented in accordance with the approved scheme.

12. Any facilities for storage of oils, fuels or chemicals on the site shall be sited in impervious bases and surrounded by impervious bund walls. The volume of the bunded compound shall be at least equivalent to the capacity of the tank plus 10%. If there is multiple tankage, the compound shall be at least equivalent to the capacity of the largest tank, or the combined capacity of inter-connective tanks, plus 10%. All filling points, vents, gauges and site glasses shall be located within the bund. The drainage system of the bund shall be sealed with no discharge to any water course, land or underground strata. Associated pipe-work shall be located above ground and protected from accidental damage.

13. Measures shall be taken to minimise the risk of groundwater pollution from quarrying operations, in accordance with the following protocol:

    - All mobile plant using fuel should be located on hard standing when not in use;
    - All immobile plant using fuel should be located on hard standing. Drip trays should also be appropriately placed under all relevant plant;

    - All refuelling activities should be undertaken on areas of hard standing, using appropriate care and attention;

- An incident reporting procedure should be maintained for reporting all site incidents, including pollution events. Suitable emergency responses should also be in place in the event of an incident.
- Appropriate spill kits or other means of controlling accidental spills should be made available on site. Adequate training in the use of such equipment should also be provided;

- A maintenance and inspection programme should be followed in order to check the condition of site equipment and provide early warning of any potential leaks or spills;

- Suitable waste management procedures should be followed to prevent surface pollution resulting from any waste products, fuel containers, chemical drums;

- During site restoration all permanent plant and equipment should be removed from the quarry;

- The use of herbicides and other related chemicals should be restricted both during quarry working and post restoration. Chemical applications should be made at appropriate times, in suitable quantities, so to avoid sub surface contamination.

Nature Conservation

14. Measures shall be taken to minimise disturbance of habitats and interference with species, in accordance with the following protocols:

    a. Any large trees or large crevices in undisturbed parts of the quarry shall be inspected for possible bat presence immediately ahead of any tree surgery or quarrying works. Any bats which are identified shall be dealt with in accordance with current legislation and best practice;

    b. Clearance of trees and scrub should avoid the main bird nesting season (March to August inclusive);

    c. Common reptiles encountered during works should be allowed to leave the immediate works area unharmed, and, if necessary, should be assisted by means of capture and release;

    d. Dense ruderal and grassland vegetation should be strimmed and raked away at least 24 hours ahead of earthworking, so as to reduce the attractiveness of the area for reptiles, and encourage them to leave; and

    e. Written protocols shall be issued to contractors so that in the event of discovery of bats, nesting birds, badgers or common reptiles, compliance with statutory obligations is ensured.

Landscape

15. Within 12 months of the date of determination of this submission a scheme shall be submitted to and agreed in writing by the MPA detailing the fencing out of Tree Preservation Order woodland adjoining the western boundary of the site. The scheme shall be implemented as agreed in accordance with a timetable to be agreed.

16. Within 12 months of the date of determination of this submission a scheme of landscaping shall be submitted to and approved by the MPA. Such a scheme shall provide for:

    a. The landscaping of all peripheral areas of the quarry which would help to screen quarrying operations from adjoining land/settlement and enhance landscape/wildlife interests. Details such as the cultivation of soils, spacing, density and species shall be provided together with the need for protective tree shelters/rabbit guards as appropriate;

    b. Infill, widening and strengthening of the woodland belt along the western boundary of the proposed quarry void (adjacent to Lamb Row and Rock Cottages as well as adjacent to the weighbridge and offices);

    c. The progressive landscaping of quarry benches where possible; and

    d. All trees, shrubs and hedges planted in accordance with the approved scheme shall be maintained and any plants which within 5 years of planting die, are removed or become seriously damaged or diseased shall be replaced in the next planting season with others of a similar size and species.

    All planting shall be carried out in accordance with the approved scheme within the first planting season following the date of its approval.

17. A stockproof fence, minimum height 1.30 metres, with appropriate warning signs, shall be maintained around the entire perimeter of the site.

Noise

18. Except for temporary operations, the free-field Equivalent Continuous Noise Level, $L_{Aeq,1\ hour}$ due to operations in the site, shall not exceed the relevant criterion limit specified in Schedule 1 at each nominated dwelling for the periods specified. Measurements taken to verify compliance shall have regard to the effects of extraneous noise and shall be corrected for any such effects.

Schedule 1 Noise Criteria Limits

Location	**06:00-07-00** **Criterion** dB $L_{Aeq, T}$	**07:00-19:00** **Criterion** dB $L_{Aeq, T}$	**19:00-22:00** **Criterion** dB $L_{Aeq, T}$	**22:00-06:00** **Criterion** dB $L_{Aeq, T}$
Rock Cottages	42	50	48	42
Sea View, Mount Pleasant Road	45	50	48	42
Ty Tanglwyst Farm	42	55	48	42
Cornelius Close	42	55	48	42

19. For temporary operations such as site preparation, soil and overburden stripping, bund formation and removal and final restoration, the free-field noise level due to work at the nearest point to each dwelling shall not exceed 67 dB $L_{Aeq, 1 hour}$. Temporary operations shall not exceed a total of eight weeks in any calendar year for work close to any individual noise sensitive properties.

Blasting

20. Except with the written consent of the MPA, or in the case of emergency, blasting operations shall be carried out only between 1000 and 1700 hours Monday to Friday, and only in exceptional circumstances on Saturday and not at all on Sunday and Public/Bank Holidays.

21. Ground vibration as a result of blasting shall not exceed a peak particle velocity of 6mms-1 in 95% of all blasts measured over any six month period, and no individual blast shall exceed a peak particle velocity of 10mms-1 measured at any vibration sensitive location, which is defined as any residential property in the vicinity of the quarry existing at the Date of

Determination. The measurements shall be the maximum of three perpendicular directions taken at the ground surface. The monitoring locations shall be agreed with the MPA.

22. No blast shall be undertaken closer than 125m of Rock Cottages until a report has been submitted to and approved in writing by the MPA to demonstrate how the vibration limits specified in Condition 21 will be met. The report shall be carried out by a qualified vibration consultant and shall include the following information:

    a) the predicted vibration levels of the nearest sensitive receptor taking into account the Council's vibration results measured as a PPV on the 5th October 2009 at a proximity of 125m from the blast area which were:
    - Longitudinal 14.4mm/s
    - Vertical 10.8mm/s
    - Transverse 21.6 mm/s; and

    b) the design of the blast and the Maximum Instantaneous Charge (MIC) that will be required to achieve the limits specified in Condition 21.

23. A minimum of 24 hrs notice shall be given to the MPA of any blasting that is to be carried out within the Quarry that is closer than 125m to Rock Cottages together with details of the proposed blast design.

24. A minimum of 24 hrs notice shall be given to the MPA of all blasting at the Quarry.

25. All individual blasts shall be designed, managed and implemented to minimise the extent of air overpressure resulting from blasts. Such effort shall have regard to blast design, methods of initiation of blasts, and also as far as practicable to weather conditions prevailing at the time of initiation.

26. Each individual blast shall be monitored by the Operators, to include provision for recording the details and location of the monitoring station; the location of the blast holes within the Site; weather conditions; specification of the blast in terms of MIC; and total charge weight. Records of blast monitoring shall be made available to the MPA upon request. Any complaints which are received shall be logged against each particular blast. In the event that monitoring indicates that the vibration levels set out in condition 21 above have been exceeded, then the Operator shall inform the MPA within two working days, with written confirmation of the steps to be taken to ensure compliance with condition 21.

27. Blasting times shall be clearly advertised at the Quarry, and an audible warning shall be sounded prior to any blasting operations taking place, and shall be sounded again immediately after blasting has finished.

28. There shall be no secondary breakage of stone by the use of explosives.

Dust

29. Automatic vehicle cleaning facilities, including sprays to clean the wheels, underbody and side body of vehicles shall be maintained throughout the operations permitted. Such facilities shall include the provision of a water recycling system to maximise the use of water supplies.

30. At all times during the carrying out of operations, a water bowser or similar equipment shall be available on site, and be used to minimise the emission of dust from haul roads within the site.

31. Measures shall be taken to minimise dust emissions from quarrying operations, in accordance with the following protocol:

    - Soils and overburden shall not be handled during extreme dry conditions unless the working areas are first dampened down;
    - Drilling of shot holes shall be undertaken using drilling rigs fitted with a suitable dust collection system;
    - All lorries, once loaded, shall be sheeted prior to leaving the site, with the exception of any load carrying only plus 75mm size stone.
    - The speed of haulage vehicles at the site will be restricted to 10mph.
    - All site vehicles will be fitted with upswept exhausts and radiator fan shields.
    - Lorries will be loaded so as to avoid spillages.
    - All site traffic will be kept to the designated haul routes
    - Any plant spillages will be cleared to avoid accumulations.
    - Drop heights will be minimised at loading and discharge points.

Archaeology

32. At least 12 months in advance of the commencement of extraction from Phase 3 (as per Drawing 3782/04) a programme of archaeological investigation and recording in accordance with a written scheme of investigation shall be carried out by the developer. The written scheme of investigation shall be submitted to and approved in writing by the MPA, and implemented within 6 months of the date of the approval.

33. At least 14 days notice of the commencement of any soil stripping programme shall be given to the MPA and the developer shall afford access at all reasonable times to archaeologists nominated by the MPA who shall be allowed to observe the excavations and record items of interest and finds.

Restoration

34. The development shall proceed in accordance with the concept restoration plan ref numbers M13.128b.D.012 and 011 and the details of interim and final restoration treatments, landscaping, and aftercare, set out in the 2014 ES.

35. Not later than 6th January 2067, or the expiry of six months following the permanent cessation of the winning and working of minerals, whichever is the sooner, the Operator shall submit for the written approval of the MPA, a detailed final restoration scheme, including drawings to illustrate the proposals for the final restoration of the quarry. The final restoration scheme shall be based upon the concept restoration plan ref numbers M13.128b.D.012 and 011, and provide for the site to be restored as a nature conservation bias, with restoration treatment of the benches and faces above the water level which will be formed in the void. The scheme shall include updated predictions of the final rest water level of the lake. The remainder of the site shall be cleared of all plant, machinery, buildings and apparatus in accordance with the requirements of Condition 3. The restoration scheme shall include details of the final re-profiling works for the site, the soil /soil forming material profiles to be established; tree and shrub planting schedules; seeding, fencing and drainage; and a programme and timetable for the implementation of the works.

36. Not later than 6th January 2067, or the expiry of six months following the permanent cessation of the winning and working of minerals, whichever is the sooner, the Operator shall submit for the written approval of the MPA, a detailed aftercare management plan. The management plan shall be in substantial accordance with the details of the final restoration scheme and the principles of the strategic aftercare management strategy set out in Chapter 3.0 of the 2014 ES.

ANNEX D - CORNELLY AND GROVE QUARRIES IDO REVIEW

RECOMMENDED SCHEDULE OF PLANNING CONDITIONS

A: DEFINITION OF TERMS

For the purposes of these planning conditions the following words and phrases shall have the meaning given to them below:

i. "IDO Area" means the IDO permission ref 53/93/1350 which is the subject of an application submitted to Bridgend County Borough Council under the provisions of Schedule 14 of the Environment Act 1995 for a Review of the planning conditions regulating quarrying operations within the IDO area of Cornelly and Grove Quarries (ref P/97/738/MIN), shown outlined in blue on Plan 1 accompanying this schedule of conditions.

ii. "The eastern IDO area" means that part of the IDO permission ref 53/93/1350 which lies within Cornelly Quarry, and which is shown coloured pink on Plan 1 accompanying this schedule of conditions.

iii. "The western IDO area" means that part of the IDO permission ref 53/93/1350 which lies within Grove Quarry, and which is shown coloured yellow on Plan 1 accompanying this schedule of conditions.

iv "Grove ROMP Area" means the western area of Grove Quarry which is subject to a separate application submitted to Bridgend County Borough Council under the provisions of Schedule 13 of the Environment Act 1995 for a Review of the planning conditions regulating quarrying operations within the ROMP area of Grove Quarry (ref P/97/618), shown outlined in purple on Plan 1 accompanying this schedule of conditions.

v "Grove ROMP Application" means the application submitted to Bridgend County Borough Council under the provisions of Schedule 13 of the Environment Act 1995 for a Review of the planning conditions regulating quarrying operations at Grove Quarry (ref P/97/618).

vi "Cornelly ROMP Area" means the eastern and northern areas of Cornelly Quarry area subject to the application submitted to

Bridgend County Borough Council under the provisions of Schedule 13 of the Environment Act 1995 for a Review of the planning conditions regulating quarrying operations at Cornelly Quarry (ref P/97/623), shown outlined in red on Plan 1 accompanying this schedule of conditions.

vii "Cornelly ROMP Application" means the application submitted to Bridgend County Borough Council under the provisions of Schedule 13 of the Environment Act 1995 for a Review of the planning conditions regulating quarrying operations at Cornelly Quarry (ref P/97/623).

viii "Date of Determination" means the date upon which new conditions subsequent to the applications are finally determined, i.e. the date upon which all proceedings on the applications, including appeals to the Secretary of State and the High Court have been determined, and the time period for any further appeal has expired.

ix "Emergency" means any circumstances in which the operator has a reasonable cause for apprehending injury to persons or serious damage to property.

x "Mineral Planning Authority, (MPA)", means Bridgend County Borough Council, or any successor mineral planning authority.

xi. "2014 ES" means the Environmental Statement (ES) submitted in June 2014 in support of the Cornelly and Grove Quarries IDO Review application.

xii. "Quarrying operations" means winning and working of stone from the quarry face, and the operation of the primary crusher/or other mechanical means of stone breaking.

xiii. "Temporary operations" means operations associated with soil and overburden stripping, construction of soil storage mounds, construction of site haul roads, construction of soil baffle mounds, and restoration works involving the use of machinery. Temporary operations are to be confined to a period of no more than 8 weeks in a calendar year.

B TIME LIMITS

1. Quarrying operations within the eastern and western IDO areas shall be completed by 31st December 2056.
2. Following the completion of quarrying operations in the eastern and western IDO areas, all extraction, treatment, and stockpiling of minerals shall cease.

3. No later than 12 months following the completion of quarrying operations in the eastern and western IDO areas, or the earlier permanent cessation of winning and working of minerals, all plant, machinery and structures shall be dismantled and removed from the site.

4. No later than 12 months following the expiry of the planning permission, or the earlier permanent cessation of winning and working of minerals, as agreed by both the mineral operator and MPA, the sale and transportation of minerals to and from the IDO area, together with all ancillary manufacturing activities shall cease.

C WORKING PROGRAMME

5. Unless otherwise approved in writing by the MPA, the winning and working of stone and disposal of overburden/quarry waste shall be carried out in the eastern IDO area in accordance with the updated quarry development plan ref numbers C112/097 - C112/105, and in the western IDO area in accordance with the updated quarry development plan ref numbers G057/016 - G057/019.

6. The site accesses to Cornelly and Grove Quarries shall be surfaced in permanent materials, and the surface maintained in a good state of repair, and kept free of mud/debris at all times.

7. Within the eastern IDO area, quarrying operations shall take place only between the hours of 06:00 - 22:00 Mondays to Saturdays, and at no time on Sundays or Bank Holidays, except for essential maintenance or otherwise agreed in writing by the MPA.

   (NB (i) *For the purpose of this condition, quarrying operations shall be defined as winning and working of stone from the quarry face, and the operation of the primary crusher/or other mechanical means of stone breaking.*

   (ii) *The hours of operation for all other items of plant within the eastern IDO area, including secondary crushers, screens, sinter mills, asphalt plant, and concrete plant, are unrestricted in terms of hours of working*).

8. Within the working hours specified in Condition 7, there shall be no drilling operations, or secondary breakage of stone between the hours of 06:00 – 07:00 and 19:00 - 22:00 hours.

9. Within the western IDO area, quarrying operations shall take place only between the hours of 07:00 - 19.00 Mondays to Fridays and 07.00 – 13.00 on Saturdays, and at no time on Sundays or Bank Holidays, except for essential maintenance or as otherwise agreed in writing by the MPA.

10. No operations associated with the formation and subsequent removal of material from bunds/soil storage areas shall be carried out at the site except between the hours of 08:00 – 17:00 Mondays to Fridays, and 08:00 - 13:00 on Saturdays.

11. Temporary operations, as defined, shall only be carried out between 08:00 – 19:00 hours Mondays to Fridays.

D ENVIRONMENTAL PROTECTION

Hydrology and Hydrogeology

12. The water management, monitoring, reporting, mitigation and contingency activities set out in the Water Management Plans (WMPs) for Cornelly Quarry v5.8 and Grove Quarry v5.8 dated 9th November 2015 shall be carried out throughout the life of the development.

13. In the event that the Minerals Planning Authority requires changes to the WMPs, as provided for in the WMPs, then the amended water management, monitoring, reporting, mitigation and contingency activities requested by the Minerals Planning Authority shall be carried out for the remaining life of the development.

14. Prior to the cessation of dewatering, a scheme shall be submitted to and approved in writing by the Minerals Planning Authority setting out proposals for residual pumping during the quarry decommissioning stage. The scheme shall include details of the rates and timescale of residual pumping, and the measures to be taken to monitor the effectiveness of the residual pumping during the defined time period. The scheme shall thereafter be implemented in accordance with the approved scheme.

15. Any facilities for storage of oils, fuels or chemicals on the site shall be sited in impervious bases and surrounded by impervious bund walls. The volume of the bunded compound shall be at least equivalent to the capacity of the tank plus 10%. If there is multiple tankage, the compound shall be at least equivalent to the capacity of the largest tank, or the combined capacity of inter-connective tanks, plus 10%. All filling points, vents, gauges and site glasses shall be located within the bund. The drainage system of the bund shall be sealed with no discharge to any water course, land or underground strata. Associated pipe-work shall be located above ground and protected from accidental damage.

16. To minimise the risk of groundwater pollution from quarrying operations, the development shall be carried out in accordance with the following requirements**:**

- All mobile plant which requires fuel for its operation should be located on hard standing when not in use.
- All immobile plant which requires fuel for its operation should be located on hard standing. Drip trays should also be appropriately placed under all relevant plant.
- All refuelling activities should be undertaken on areas of hard standing, taking appropriate care and attention.
- An incident reporting procedure should be maintained for reporting all site incidents, including pollution events. Emergency responses should also be in place in the event of an incident.
- Appropriate spill kits or other means of controlling accidental spills should be made available on site. Adequate training in the use of such equipment should also be provided.
- A maintenance and inspection programme should be followed in order to check the condition of site equipment and provide early warning of any potential leaks or spills.
- Suitable waste management procedures should be followed to prevent surface pollution resulting from any waste products, fuel containers, and chemical drums.
- During site restoration all hazardous plant and equipment should be removed from the quarry.
- The use of herbicides and other related chemicals should be restricted both during quarry working and post restoration. Chemical applications should be made at appropriate times, in suitable quantities, so to avoid sub surface contamination.

Ecology

17**.** Within 6 months of the date of determination, an Ecological Mitigation Strategy (EMS) shall be submitted to the MPA for their approval in writing. The EMS shall include the mitigation measures set out in Section 8.7 of the 2014 ES. The EMS shall thereafter be implemented as approved.

18. In addition to the measures to be included in the EMS, in order to minimise disturbance of habitats and interference with species, the development shall be carried out in accordance with the following requirements:

(i) Calcareous grasslands on the fringes of Cornelly and Pant Mawr Quarries, which would be unaffected by the development scheme, shall be fenced to prevent accidental incursion of vehicles and site personnel;

(ii) Areas of inaccessible high cliff shall be identified each year, and, subject to operational requirements shall be left undisturbed in order to encourage potential habitat for nesting peregrine falcons;

(iii) Any large trees or large crevices in undisturbed parts of the quarry shall be inspected for possible bat presence immediately ahead of any tree surgery or quarrying works. Any bats which are identified shall be dealt with in accordance with current legislation and best practice;

(iv) Clearance of trees and scrub should avoid the main bird nesting season (March to August inclusive);

(v) Common reptiles encountered during works should be allowed to leave the immediate works area unharmed, and, if necessary, should be assisted by means of capture and release;

(vi) Dense ruderal and grassland vegetation should be strimmed and raked away at least 24 hours ahead of earthworking, so as to reduce the attractiveness of the area for reptiles, and encourage them to leave;

(vii) Written protocols shall be issued to contractors so that in the event of discovery of bats, nesting birds, badgers or common reptiles, compliance with statutory obligations is ensured.

Landscaping

19. Within 6 months of the date of determination a scheme shall be submitted to the MPA for their approval in writing setting out proposals for the beating up and infilling the existing hedgerow alongside the southern boundary of the Cornelly ROMP area and western IDO area abutting Mount Pleasant Road. The scheme shall include proposals for the timescale for implementation of the works, which shall thereafter be implemented in accordance with the approved scheme.

20. Within 6 months of the date of determination a scheme shall be submitted to the MPA for their approval in writing setting out proposals for the construction of a 2.0m high screening bund along the southern boundary of the western IDO area abutting Mount Pleasant Road. The scheme should include provision for the bund to be constructed with an outer gradient of no steeper than 1:2 (v/h) and grass seeded and planted with native trees and shrubs to provide a vegetated visual barrier to views. The scheme shall include proposals for the timescale for implementation of the works, which shall thereafter be implemented in accordance with the approved scheme.

21. Within 6 months of the date of determination a scheme shall be submitted to the MPA for their approval in writing setting out proposals for the infilling, widening and strengthening of the hedgerow/woodland belt along the northern boundary of the eastern IDO area. The scheme shall include proposals for the timescale for implementation of the works, which shall thereafter be implemented in accordance with the approved scheme.

22. Within 6 months of the date of determination a scheme shall be submitted to the MPA for their approval in writing setting out proposals for the infilling and strengthening of the woodland belt along the lower sections of the wooded northern flank of the western IDO area along the Heol y Splot corridor. The scheme shall include proposals for the timescale for implementation of the works, which shall thereafter be implemented in accordance with the approved scheme.

23. Within 6 months of the date of determination a scheme shall be submitted to the MPA for their approval in writing setting out proposals for the intermediate restoration of the upper faces/benches illustrated on plan ref numbers C112/097- C112/105. The restoration works shall thereafter be implemented in accordance with the approved scheme.

Noise

24. Except for temporary operations, the free-field Equivalent Continuous Noise Level, $L_{Aeq,1\ hour}$ due to operations in the eastern IDO area shall not exceed the relevant criterion limit specified in Schedule 1 at each nominated dwelling for the periods specified. Measurements taken to verify compliance shall have regard to the effects of extraneous noise and shall be corrected for any such effects.

Schedule 1 Noise Criteria Limits: Eastern IDO Area

Location	**07:00-19:00** **Criterion** dB $L_{Aeq, T}$	**06:00-07-00** **Criterion** dB $L_{Aeq, T}$	**19:00-22:00** **Criterion** dB $L_{Aeq, T}$	**22:00-06:00** **Criterion** dB $L_{Aeq, T}$
Rock Cottages in South Cornelly	50	42	48	42
Danygraig (Holiday Caravan Camp)	55	45	48	42
Grove Farm House, Grove	55	45	48	42
Sea View, Mount Pleasant Road	50	45	48	42
Manderlay, Stormy Down	55	48	48	42
Ballas Farm	55	48	48	42
Ty Tanglwyst Farm	55	48	48	42
Mount Pleasant Farm	53	45	48	42

25 Except for temporary operations, the free-field Equivalent Continuous Noise Level, $L_{Aeq,1\ hour}$ due to operations in the western IDO area shall not exceed the relevant criterion limit specified in Schedule 2 at each nominated dwelling for the periods specified. Measurements taken to verify compliance shall have regard to the effects of extraneous noise and shall be corrected for any such effects.

Schedule 2 Noise Criteria Limits: Western IDO Area

Location	**07:00-19:00** **Criterion** dB $L_{Aeq,\ T}$
Rock Cottages in South Cornelly	55
Danygraig (Holiday Caravan Camp)	55
Grove Farm House, Grove	55
Sea View, Mount Pleasant Road	55
Manderlay, Stormy Down	55
Ballas Farm	55
Ty Tanglwyst Farm	55
Mount Pleasant Farm	53

.

26. For temporary operations such as site preparation, soil and overburden stripping, bund formation and removal and final restoration, the free-field noise level due to work at the nearest point to each dwelling shall not exceed 67 dB $L_{Aeq,\ 1\ hour}$. Temporary operations shall not exceed a total of eight weeks in any calendar year for work close to any individual noise sensitive properties.

Blasting

27. Except with the written consent of the MPA, or in the case of emergency, blasting operations shall be carried out only between 1000 and 1700 hours Monday to Friday, and only in exceptional circumstances on Saturday and not at all on Sunday and Public/Bank Holidays.

28. Ground vibration as a result of blasting shall not exceed a peak particle velocity of 6mms^{-1} in 95% of all blasts measured over any six month period, and no individual blast shall exceed a peak particle velocity of 10mms^{-1} measured at any vibration sensitive location, which is defined as any residential property in the vicinity of the quarry existing at the Date of Determination. The measurements shall be the maximum of three perpendicular directions taken at the ground surface.

29. All individual blasts shall be designed, managed and implemented to minimise the extent of air overpressure resulting from blasts, having regard to blast design, methods of initiation of blasts, and also as far as practicable to weather conditions prevailing at the time of initiation.

30. Each individual blast shall be monitored by the Operators, to include provision for recording the details and location of the monitoring station; the location of the blast holes within the Site; weather conditions; specification of the blast in terms of MIC; and total charge weight. Blast monitoring is to be undertaken at the closest sensitive receptor to the blast location or at an alternative location that is requested by the Mineral Planning Authority. Records of blast monitoring shall be made available to the MPA upon request. Any complaints which are received shall be logged against each particular blast. In the event that monitoring indicates that the vibration levels set out in condition 28 above have been exceeded, then the Operator shall inform the MPA within two working days, with written confirmation of the steps to be taken to ensure compliance with condition 28.

31. Blasting times shall be clearly advertised at the Cornelly and Grove Quarries, and an audible warning shall be sounded prior to any blasting operations taking place, and shall be sounded again immediately after blasting has finished.

32. There shall be no secondary breakage of stone by the use of explosives.

Dust

33. At all times during the carrying out of operations, a water bowser or similar equipment shall be available within the IDO area, and be used to minimise the emission of dust from haul roads and access roads within the site, and the processing plant site hard-standings.

34. Measures shall be taken to minimise dust emissions from quarrying operations, in accordance with the following protocol:

    - Soils and overburden shall not be handled during extreme dry conditions unless the working areas are first dampened down;

- Drilling of shot holes shall be undertaken using drilling rigs fitted with a suitable dust collection system;
- Site roads within the quarry shall be dampened down as appropriate, in accordance with the requirement of condition 33;
- The site entrance road shall be maintained by use of a road sweeper which shall operate as required to maintain the surface of the road free of mud and other detritus.
- All lorries, once loaded, shall be sheeted prior to leaving the site, with the exception of any load carrying only plus 75mm diameter stone.
- The speed of haulage vehicles at the site will be restricted to 10mph.
- All site vehicles will be fitted with upswept exhausts and radiator fan shields.
- Lorries will be loaded so as to avoid spillages.
- All site traffic will be kept to the designated haul routes
- Any plant spillages will be cleared to avoid accumulations.
- Drop heights will be minimised at loading and discharge points.

Restoration

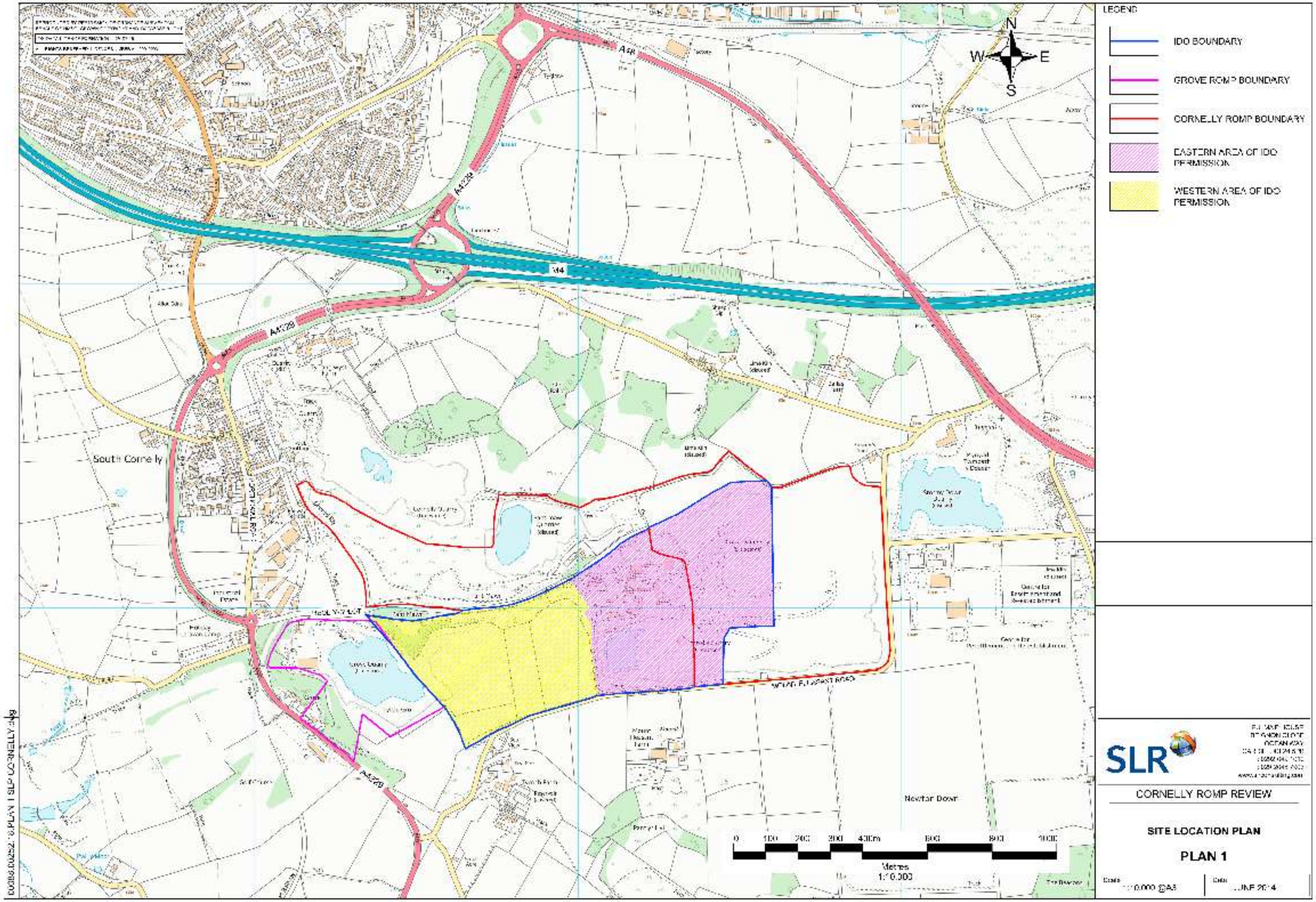
35 The development shall proceed in accordance with the concept restoration plan ref numbers C112/106 - C112/108 for the eastern IDO area and Cornelly ROMP area, and plans G057/020 - G057/021 for the western IDO area and Grove ROMP area, and the details of interim and final restoration treatments, landscaping, and aftercare, set out in Chapter 4.0 of the 2014 ES.

36. Not later than 31st December 2054, or the expiry of six months following the permanent cessation of the winning and working of minerals, whichever is the sooner, the Operator shall submit for the written approval of the MPA, a detailed final restoration scheme, including drawings to illustrate the proposals for the final restoration of the quarry. The final restoration scheme shall be based upon the concept restoration plan ref numbers C112/106 - C112/108 for the eastern IDO area and plan ref numbers G057/020 - G057/021 for the western IDO area, and provide for the site to be restored as a nature conservation bias, with restoration treatment of the benches and faces above the water level

which will be formed in the void. The scheme shall include updated predictions of the final rest water level of the lake. The remainder of the site shall be cleared of all plant, machinery, buildings and structures in accordance with the requirements of Condition 3. The restoration scheme shall include details of the final re-profiling works for the site, the soil /soil forming material profiles to be established; tree and shrub planting schedules; seeding, fencing and drainage; and a programme and timetable for the implementation of the works.

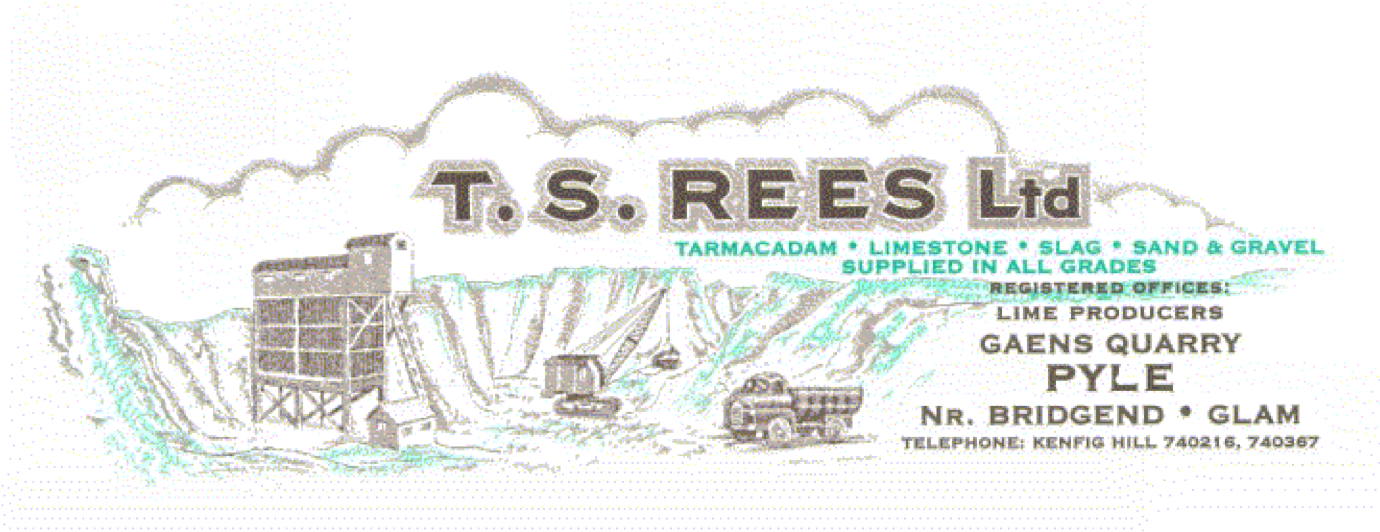
37 Not later than 31st December 2054, or the expiry of six months following the permanent cessation of the winning and working of minerals, whichever is the sooner, the Operator shall submit for the written approval of the MPA, a detailed aftercare management plan. The management plan shall be in substantial accordance with the details of the final restoration scheme and the principles of the strategic aftercare management strategy set out in Chapter 4.0 of the 2014 ES.

ANNEX E – Plan 1 referred to in Definition of Terms in Annexes A, B and D for Cornelly and Grove Quarries


LEGEND
IDO BOUNDARY
GROVE ROMP BOUNDARY
CORNELLY ROMP BOUNDARY
EASTERN AREA OF IDO PERMISSION
WESTERN AREA OF IDO PERMISSION
N
W
E
S
M4
A48
A4229
South Cornelly
Newton Down
0
100
200
300
400m
600
800
1000
Metres
1:10,000
CORNELLY ROMP REVIEW
SITE LOCATION PLAN
PLAN 1
Scale
1:10,000 @A3
Date
JUNE 2014

Appendix C

Environmental Impact Assessment (relevant sections)



VOLUME 1

ENVIRONMENTAL STATEMENT

ENVIRONMENT ACT ROMP REVIEW:

GAENS QUARRY
SOUTH CORNELLY, BRIDGEND

June 2014

Received in
Planning 26-6-14

CONTENTS

TABLES (within ES Volume 1)

FIGURES (within ES Volume 1)

APPENDICES (ES Volumes 2A – 2D)

APPENDICES

APPLICATION PLANS (ES Volume 3)

1.0 INTRODUCTION

1.1 Background

Gaens Quarry, located in South Cornelly near Porthcawl, is a long established hard rock quarry that produces crushed rock aggregates and related products for the construction and infrastructure markets. The quarry has the benefit of long-standing planning permissions for the activities undertaken on the site. The location of the site is illustrated on Figure 1-1 (Site Location).

T. S. Rees Limited as owner and operator of the quarry is making a submission for the determination of new planning conditions to be attached to the existing planning permissions at the quarry.

Schedule 14 of the Environment Act 1995 provides for a 15 yearly periodic review of minerals planning permissions (ROMPP). The legislation places a requirement on the relevant Mineral Planning Authority (MPA) to notify the owner and operator of mineral sites of the review requirement, who in turn are then obliged to submit, to the MPA for approval, a scheme of new conditions that are to be applied to the mineral planning permissions.

The submission is fundamentally different from the majority of other planning submission in that it wholly relates to development that is already authorised and being undertaken. The submission does not itself contain any proposals for new development but will provide sufficient information to assist the planning authority in determining a revised set of planning conditions under which the quarry will be developed up to the point of the next periodic review.

The ROMP application was originally submitted to Bridgend County Borough Council (as MPA) in 1997. It was called in by the Welsh Office (now Welsh Government) in May 1998 for determination by the Secretary of State for Wales (now the Welsh Ministers). The application remains undetermined, and is now regarded as a 'stalled ROMP application', which is subject to the procedural requirements set out in the 'Stalled ROMP Regulations 2009' (discussed further below).

Separate ROMP applications have been submitted by Tarmac (now Lafarge Tarmac) relating to the nearby quarries at Cornelly and Grove. The location of these quarries is shown on Figure 1-2. These applications have also been called-in by the Welsh Government, and are subject to the same 'stalled ROMP' procedural requirements.

The underlying reason for the call in of the applications was concern that the ongoing quarry developments, involving deepening below the water table and associated dewatering, might impact upon the Kenfig Special Area of Conservation (SAC) and the hydrology of the dune system at Kenfig Pool, located some 2.5 kilometres to the north west of the quarries. The Kenfig SAC also includes the dune system at Merthyr Mawr, located some 2.5 kilometres to the south east. The primary concern relates to Cornelly Quarry which is an extensive operation, with a circa one million tonnes per annum (tpa) output, with proposals to deepen the quarry to -75m AOD.

Gaens Quarry is a more modest enterprise, with an average 150,000 tpa output, and aspirations to deepen the floor of the quarry to no lower than -20m AOD. Separate Environmental Impact Assessments (EIAs) have been undertaken and Environmental Statement (ES's) produced for Cornelly and Grove Quarries, and consideration has been given to interrelationships with those parallel EIA's in terms of cumulative effects.

In August 2000, the National Assembly (now Welsh Government) requested the respective Applicants to voluntarily undertake EIA's in support of the ROMP applications. This request was made on the basis of concern that the development would be likely to have significant effects on the environment, having regard in particular to, inter alia, "t*he potential impact of quarrying on Kenfig Pool and Dunes SSSI, a site of European importance being a candidate Special Area of Conservation"*. Both TS Rees Ltd and Tarmac confirmed their willingness to cooperate with this request, and jointly commissioned ESI Ltd to undertake hydrogeological assessments of the respective quarries.

A series of preliminary and draft technical studies in respect of Gaens Quarry were prepared between 2003 and 2009, however, prior to the completion of these studies and the preparation of an ES, the Welsh Government issued the 'Stalled ROMP Regulations (December 2009), and the intention to submit a voluntary ES in support of the Gaens ROMP Review application was overtaken by the formalised requirements of the Regulations.

1.2 Environment Act Review

1.2.1 'ROMP' Applications

Quarrying at Gaens commenced in the early 1900's, and was formalised by an Interim Development Order (IDO) permission granted in 1948. More recently planning permissions for extensions to the original quarry were granted in 1949, 1963, 1967, and 1968. Gaens Quarry was acquired by TS Rees Ltd in 1982. The extent of the historic permissions is illustrated on Figure 1-3.

The 1948 IDO permission was not formally registered as required by the Planning and Compensation Act 1991. The permission accordingly lapsed in 1992. The current Environment Act ROMP Review relates to the central and eastern areas of the quarry, as defined in red on Drawing 3782/01: Existing Quarry Layout. The original IDO area, outlined in blue on Drawing 3782/01 is relevant in that it represents 'ancillary mining land' and contains operational elements of the quarry including the weighbridge and office. A separate and stand alone permission in respect of the access road to Porthcawl Road was permitted in 1973 (ref: 425/39/73). In order to ensure that a comprehensive approach to the site is achieved, the restoration strategy for the ROMP area has been extended to include the IDO area.

1.3 Scoping Direction

In March 2013, the Welsh Government issued a formal 'Scoping Direction' setting out the issues which need to be addressed in an EIA to be undertaken in connection with the Gaens Quarry ROMP application. A copy is enclosed as Appendix 1/1. Scoping Directions have been issued in similar terms to Lafarge Tarmac in relation to Cornelly and Grove quarries.

The Scoping Direction confirms that the results of the EIA need to be set out in an ES to be submitted to the Welsh Government by 31st March 2014. The Scoping Direction is accompanied by a 'Shadow Appropriate Assessment Template' which anticipates that the determining Authority (Welsh Ministers) will need to undertake an 'appropriate assessment' under the provisions of the Habitats Directive as part of the determination process. The ES will therefore need to include information sufficient to inform any 'appropriate assessments' which are undertaken.

It is apparent from the Scoping Direction that the key environmental issue relates to ecology/hydrogeology, and the potential indirect effects of quarry dewatering on potential sensitive features within the Kenfig and Merthyr Mawr Site of Special Scientific Interest (SSSI) and Kenfig SAC. As noted above, ESI Limited have been responsible for undertaking wide ranging surveys and investigations, and for implementing a substantial programme of ground and surface water monitoring which is ongoing. Discussions have been held with the NRW (formerly Environmental Agency) aimed at refining the scope of the additional and updated studies which have been undertaken, and that engagement with the NRW has continued throughout the EIA process.

Atmos Consulting Ltd has been appointed jointly by T.S. Rees Limited to deal with ecological issues at Cornelly, Grove and Gaens Quarries, in conjunction with ESI, to assess the potential indirect effects on the SAC / SSSI and to identify mitigation measures which are available. Without wishing to underplay the importance of other environmental issues, the ecology/hydrogeology impacts form key elements of the EIA's and ES's, with added importance associated with the need for the Welsh Ministers to undertake a parallel appropriate assessment of the significance of the effects of the development on the SAC.

At Gaens Quarry, consideration has also been given to amenity issues in terms of noise and blast vibration, given the relative proximity to residential properties at South Cornelly, and access, where HGV's from the quarry need to utilise the road through the eastern outskirts of South Cornelly village to reach the primary road at the A4229 roundabout of the South Cornelly by pass.

In order to provide clarity of the content of the Scoping Opinion and how the matters raised have been addressed, Table 1/1 sets out a summary of the following:

- the requirements of the Scoping Opinion, which can be found in full at Appendix 1/1.
- the response to each requirement broken down by each subject; and
- the location within this ES at which the response is addressed.

1.4 The Environmental Statement

Planning permission for quarrying at Gaens Quarry already exists. The principle of quarrying is therefore not an issue for re-consideration as part of this submission, unless the environmental effects are deemed to be of such significance that the existing planning permissions should be formally revoked or modified in a way which would affect the asset value of the quarry. If that were to occur then compensation would be payable to the Applicant for the loss of the mineral asset.

The purpose of the ES is to assist in identifying environmental effects, and to use that knowledge and information to draft up-to-date planning conditions which will control future quarrying in a way which is environmentally acceptable.

This ES comprises Volume 1 of a four-volume submission to accompany the proposed planning conditions. The full submission includes:

- Volume 1: Environmental Statement (ES);
- Volume 2: Technical Appendices
- Volume 3: Application Drawings; and
- Volume 4: Non-Technical Summary (NTS).

The ES draws together the inputs from the specialist technical consultants who have undertaken the EIA, and is intended to be a self-contained document which covers all relevant topics.

The Statement is accordingly sub-divided into four parts, namely:

- **Baseline information**, which provides, at Chapter 2, a detailed description of the site and its surroundings as they currently exist.

- **The proposed development**, which provides, at Chapters 3 and 4, the details and nature of the extraction and restoration scheme, and related operations.

- **Environmental effects** of the development, which sets out in detail, in Technical Chapters 5-13, the potential effects of the development in terms of hydrology and hydrogeology, ecology, landscape and visual impact, noise, blast vibration, dust, traffic, and cultural heritage, and which provides, via Chapter 14.0, a summary of impacts, mitigation measures, and residual effects.

- **Planning policy and conclusions** which, in Chapters 15.0 and 16.0 provides an overview of the planning policy issues relevant to the preparation of planning conditions, and which draws conclusions regarding issues which should be addressed as planning conditions.

The schedule of new operational conditions that are proposed by T. S. Rees Limited to be applied to Gaens Quarry has also been prepared. This is submitted as a separate, stand-alone document.

The NTS has been issued as a separate document, and provides, in non-technical language, a summary of the likely implications that the continued development of the Quarry will have on the environment.

1.4.1 The Applicant

T. S. Rees Limited has owned and operated Gaens Quarry for approximately 60 years.

The quarry supplies crushed aggregate within a 25km. radius to markets in Cardiff, Bridgend, Llantrisant and Barry. The facility employs five staff directly, and contributes indirectly to employment in the local area.

1.4.2 SLR Consulting Limited (SLR)

The EIA and preparation of the ES has been undertaken on behalf of T. S. Rees Ltd by SLR Consulting Limited. SLR is a multi-disciplinary environmental and development consultancy.

SLR is a leading consultant to the minerals industry in the United Kingdom, with offices throughout the UK, including an office in Cardiff. SLR is a member of the Quarry Products Association and is represented on the National Minerals Forum and the CBI National Minerals Committee.

SLR is a registered Environmental Impact Assessor and Member of the Institute of Environmental Management and Assessment (IEMA). The company has significant experience in the preparation of planning applications and undertaking EIA for a wide variety of projects, including minerals, waste, renewable energy and infrastructure developments.

Further information on SLR Consulting Limited can be found on its corporate web site at www.slrconsulting.co.uk.

1.4.3 Publicity of the ES

Copies of the Non Technical Summary are available free of charge from:

Will Ryan
SLR Consulting Limited
Fulmar House
Beignon Close
Ocean Way
Cardiff
CF24 5PB

Copies of the ES may be purchased from the above address at a cost of £90.00 per copy, or £5.00 per CD rom.

Table 1-1: Response to Scoping Opinion	
Scoping Issue	Response
Hydrology/Hydrogeology	
The key issues are the potential hydrogeological effects of future quarrying and the management of any proposed quarry dewatering. Detailed hydrogeological assessment of the impact of future workings at Gaens Quarry on the hydrology and hydrogeology of the area should be undertaken, to include: • any potential impact which dewatering may have on surface and groundwater levels within the Kenfig/Cynffig SAC and Cefn Cribwr Grasslands SAC (and SSSIs); • potential of lateral extensions encountering groundwater within active flow paths and theconsequential impact on local abstractions or the Kenfig/Cynffig SAC and Cefn Cribwr Grasslands SAC; • hydrogeological impact assessment; • the likely impact from further quarrying on the migration of leachate and landfill gas; • the likely implications of quarrying on the stability of surrounding land; • the effects and interactions of working at Gaens Quarry with Cornelly and Grove Quaries, particularly with respect to the impact on Kenfig/Cynffig SAC and Cefn Cribwr Grasslands SAC, local abstractions and the potential for saline intrusion.	Extensive assessment has been undertaken by means of the development of a conceptual model prepared in consultation with National Resources Wales (and its predecessors). The data has been collected and analysed over the intervening period and Chapter 7.0 of this ES (and associated Appendices) addresses the issues raised in the Scoping Opinion. A Water Management Plan is included at Appendix 7/5 and summarised at Section 7.10 of this ES.
Ecology	
• The potential impacts of future quarry working/all works associated with the operation of the quarry on Kenfig/Cynffig SAC through hydrogeological	• Potential indirect impacts on Kenfig SAC considered with reference to qualifying features of the SAC; the conservation objectives; potential effects at Kenfig Dunes and Merthyr Mawr during quarrying

changes is a primary concern. • The possible impacts on Cefn Cribwr Grasslands SAC. • The presence or otherwise of any legally protected species and the extent to which they may be affected by the proposals should be established. • The ES should also address any likely significant environmental effects and necessary mitigation measures on non-statutory sites and all habitats and species listed in the UK Biodiversity Action Plan (BAP) or the Bridgend Biodiversity Action Plan (BAP).	and at restoration. • It has been concluded that Cefn Cribbwr SAC is not affected by dewatering of Cornelly Quarries. • An updated ecological study has been undertaken • Full reference to statutory and non statutory designated nature conservation sites, protected habitats and species are included as part of the ecological assessment, with reference to mitigation measures. • Chapter 6 and associated Appendices include full details of this information.
Blast Vibration	
A blast vibration assessment should be carried out to ascertain the likely impact of ground and air vibration on nearby properties, having regard to advice set out in MTAN1 and appropriate monitoring and mitigation measures identified.	Detailed blast vibration assessment has been undertaken in accordance with advice offered in MTAN1 and other guidance. Chapter 10.0 sets out the conclusions and recommends that planning conditions are imposed that comply with MTAN1.
Dust /Air Quality	
A dust assessment should be carried out to ascertain the likely effects of dust levels on the local population, flora and fauna, having regard to the advice on dust control set out in MTAN 1.	The Assessment in Chapter 11.0 has been undertaken in accordance with guidance set out in MTAN1 with reference to the existing Existing Permit and baseline data derived from monitoring. The information gathered is used to propose appropriate planning conditions to be implemented to the site throughout the operational period.
Noise	
A noise assessment should be carried out to ascertain the likely impact of noise from sources associated with the development and its likely effects on	Noise Assessment undertaken in accordance with MTAN1, but alsp drawing upon advice in TAN 11 and general comments in MPG 11 and NPPF (England).

the local population, having regard to the advice set out on noise criteria set out in MTAN1.	All information is included in Chapter 8.0.
Landscape and Visual Amenity	
The ES should describe and analyse the visual and landscape effects of the proposed quarry operations on the surrounding areas, particularly of those future operations in unworked areas within the quarry boundary. A thorough assessment should be made of the potential impact of future workings on the areas that are subject to Tree Preservation Orders and set out any proposals for future maintenance.	A detailed L&VIA has been undertaken in accordance with *Guidance for Landscape & Visual Assessment: 3rd Edition.* The L&VIA is included at Chapter 5.0 and associated Appendix. With regards to the Tree Preservation Orders, TPO ref OBC No.06 relates to the western part of the site. This was issued in 1977 and therefore post-date the extraction permission. The northern TPO is not directly affected by the extraction programme.
Transport	
The impacts of traffic arising from any increased extraction rates should be included together with proposals for traffic management and other measures to reduce impacts on the local highway, including the cleanliness of the public highway (Porthcawl Road) in South Cornelly at the junction of the site access road with the main road.	Traffic surveys were undertaken to establish baseline flows and also the number of movements associated with Gaens Quarry and other activities in the area. The findings of this work are summarised at Chapter 12.0.
Restoration	
The ES should include an assessment of the restoration proposals for the site and its proposed after-use, proposals for progressive restoration of the site, and proposals for the integration of the site into the surrounding land in conjunction with other quarries nearby.	The Restoration Strategy is included within Chapter 3 and is accompanied by Restoration Strategy Plans (Volume 3).

Figure 1-1Site Location

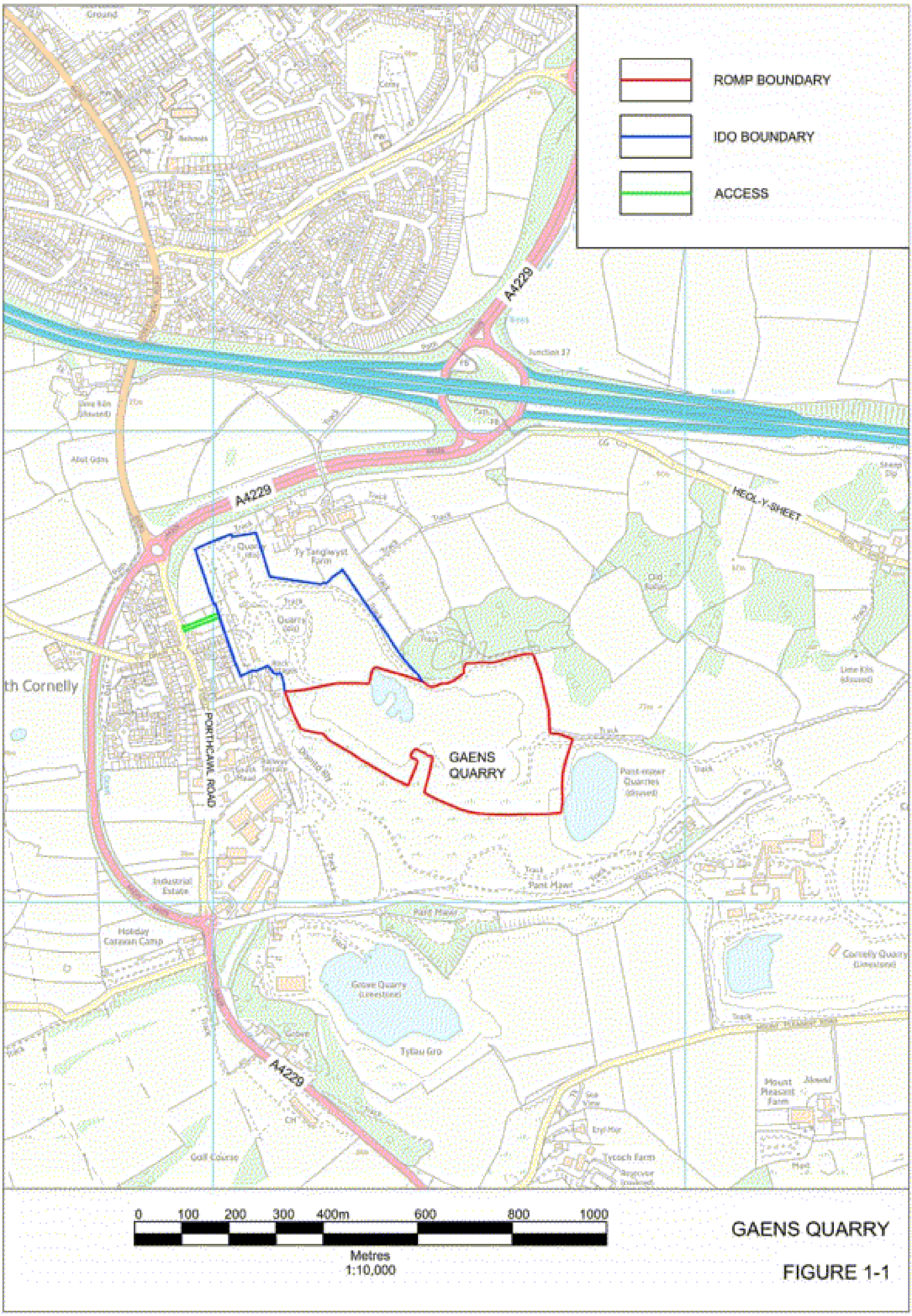


Figure 1-2 The 'Cornelly' Quarries

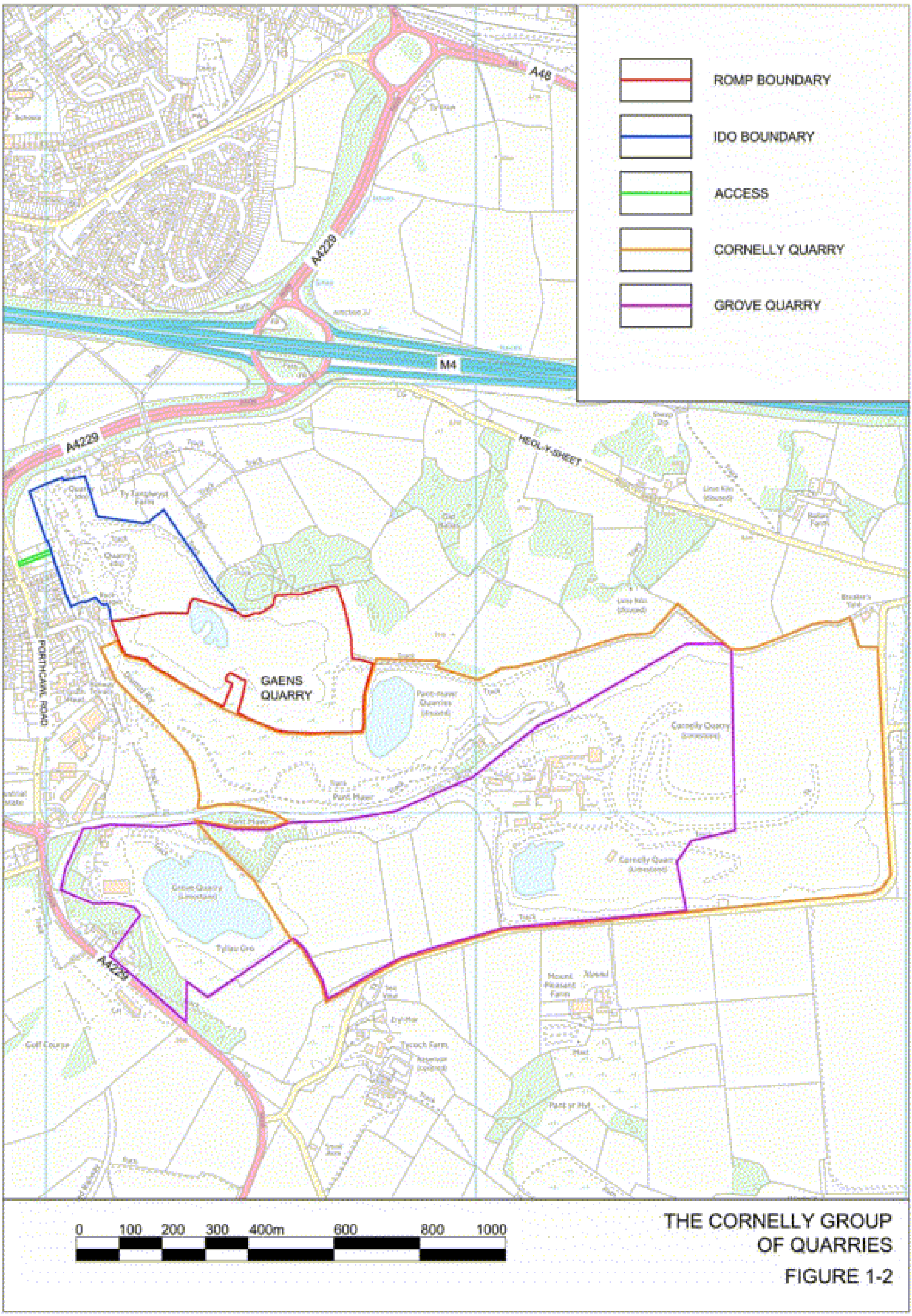
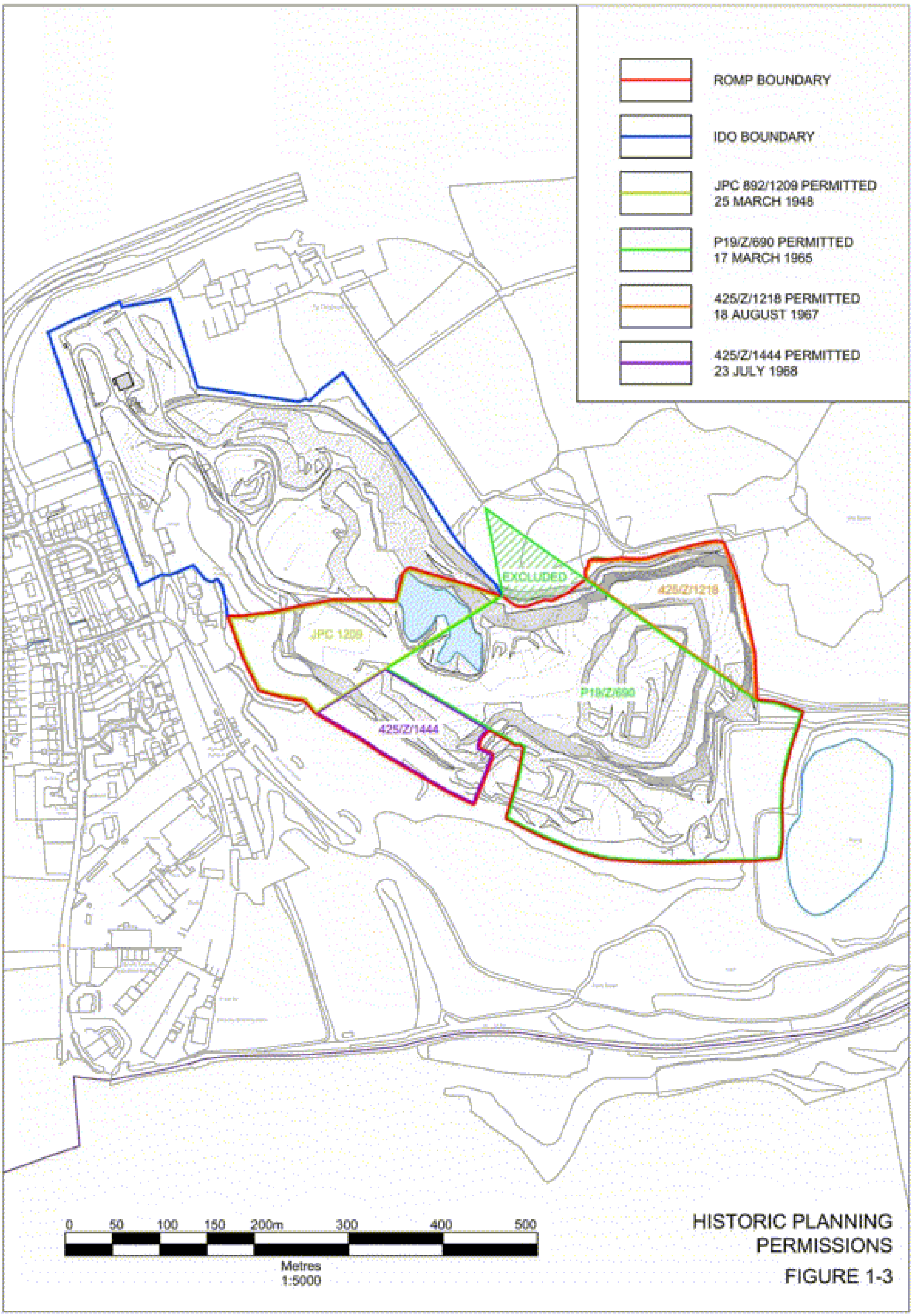


Figure 1-3 Planning History



2.0 THE APPLICATION SITE

2.1 Site Location

This chapter provides a baseline description of the site and its surroundings. The chapter is sub-divided into a series of topics, which provide a description of current circumstances, and also provide a context for the assessment of environmental effects of the development within Chapters 6.0 to 13.0.

A full appreciation of the individual environmental topics can therefore be obtained by considering the baseline description within this of the ES, against the identified environmental effects on that topic, most notably:

- Landscape and Visual Amenity: Baseline Chapter 2.3, Environmental Effects Chapter 5.0;
- Ecology: Baseline Chapter 2.4, Environmental Effects Chapter 6.0;
- Hydrology and Hydrogeology: Baseline Chapter 2.6, Environmental Effects Chapter 7.0.
- Cultural Heritage: Baseline Chapter 2.7, Environmental Effects Chapter 12.0;

The remaining impact assessment chapters 8.0-11.0 inclusive address a number of non-land use amenity issues (noise, blast vibration, dust and traffic) which are not discussed in this baseline land use description.

2.2 Application site

Gaens Quarry comprises three key elements that, together amount to some 23 hectares of land associated with current and past operations:

- the “ROMP” area associated primarily with this submission constitutes some 12.72 hectares, of which approximately 11 hectares has been previously disturbed;
- The Interim Development Order (“IDO”) land is located to the north-west of the ROMP area and extends to 8.37 hectares; and
- the access road and ancillary operations including the offices, weighbridge and fitting shop etc. are located some 100m away from the entrance, with an intervening agricultural field and behind a substantial hedgerow/tree belt.

Access to the site is via a short link road onto the Porthcawl Road which joins to the roundabout on the A4229 to the north of South Cornelly. The main quarry tip occupies a large visually prominent ridge which partly forms the southwestern boundary of the main void.

The current arrangement of the site is shown on Drawing 3782/01: Existing Layout.

2.3 Landscape Context

The Quarry is an active operation with mineral extraction currently taking place within a relatively small void within the eastern part of the ROMP area. The processing facilities are sited in two locations on the quarry floor: directly adjacent to the working void, and an array of crushing and screening plant within the southern part of the quarry.

Currently, the former quarry faces within the northwestern half of the quarry that rise northwards into higher undulating ground associated with Old Ballas woods are generally hidden from most areas and are generally weathered blending in with the surroundings, but do become visible from Heol y Broom road between South Cornelly and Pyle and Kenfig Golf Club.

Landscape Designations

Figure 2/1 illustrates the main landscape and nature conservation designations within a 20km^2 Study Area. The Site is not located within any nationally designated landscape (i.e. a National Park (NP) or an Area of Outstanding Natural Beauty (AONB)). There are no UNESCO World Heritage Sites (WHS), Ramsar, or Special Protected Areas (SPA) within 10km of the site boundary. However, a number of Special Landscape Areas, Historic Landscape Areas, Special Areas of Conservation (SAC), Scheduled Ancient Monuments, Sites of Special Scientific Interest, National and Local Nature Reserves, Site of Important Nature Conservation, Historic Parks and Gardens, Listed Buildings, areas of Ancient Woodland and Long Distance Recreational Routes are present within the Study Area (see below).

Special Landscape Areas: There are a total of four Special Landscape Areas within 3.0km of the Site. These include SLA6 Kenfig Burrows; SLA7 Laleston; SLA8 Porthcawl Coast; and SLA9 Merthyr Mawr Warren. The closest to the site is SLA6 Kenfig Burrows which lies some 1.9km to the west.

Historic Landscape Areas: There is a single Historic Landscape Area within 3.0km of the Site. Thisis the Merthyr Mawr, Kenfig & Margam Burrows HLA, although consists of two physically separate areas lying some 1.7km to the west and 3.2km to the southeast of the site.

Special Areas of Conservation (SAC): There are two SAC's within 3.0km of the Site. These include Kenfig Dunes and Burrows and Cefn Cribwr Grasslands. Although only two designations they occupy six physically distinct areas of which three are located within 3.0km of the site.

2.4 Ecology

2.4.1 Statutory Sites

The most significant statutory nature conservation sites in the vicinity are the *Kenfig Special Area of Conservation* (SAC), which covers two large and separate sand dune complexes at Kenfig and Merthyr Mawr, and the *Cefn Cribwr Grasslands SAC* which covers a group of four separate areas of grasslands. These areas enjoy the highest level of statutory protection available in the UK, being designated under the EC Directive on the Conservation of Natural Habitats of Wild Flora and Fauna 1992 (implemented in the UK via the Conservation (Natural Habitats etc) Regulations 1994) and are considered to have Europe-wide (ie international) conservation importance.

The sand dune complexes at Kenfig and Merthyr Mawr are also independently designated as National Nature Reserves (NNR), and both these and the four sites which make up the Cefn Cribwr Grasslands SAC are independently designated as Sites of Special Scientific Interest (SSSI). The SSSI and NNR designations reflect the highest level of UK-wide (ie national) importance and cover areas which extend outside of the SAC boundaries.

In addition there are three other SSSIs in the immediate vicinity, comprising *Eglwys Nunydd Reservoir*, *Waun Cimla* and *Stormy Down*. The latter comprises a cutting on the M4 motorway and some nearby disused quarries which are notified on geological grounds.

The sand dune complex at Kenfig is also designated a Local Nature Reserve (LNR), with the same boundary as the SSSI, and there is also a second LNR at Frog Pond Wood to the north-east of the site. Figure 2/1 illustrates the location of these features.

2.4.2 Non-Statutory Sites

The area around Gaens Quarry is also rich in 'third-tier' sites, which are referred to locally as Sites of Importance for Nature Conservation (SINCs). These are sites which are considered to have nature conservation significance at the county or county borough level, but which are generally of less than national significance (Figure 2/1) shows only those SINCs which lie within about 2km of Gaens Quarry. The most significant of these is Site No. CYN-1-N ('Cornelly Quarry') which includes the existing Gaens Quarry envelope, together with the adjacent Pant Mawr Quarry. Lime Kiln Wood, an area of ancient woodland which is contiguous with the northern boundary of Gaens Quarry, is also designated as a SINC (No. CYN-5-S), as is Old Ballas Wood which lies immediately to the north-east (CYN-3-N). Other SINCs lie somewhat further away to the east and south of Gaens Quarry.

2.5 Geology

2.5.1 Geology

A detailed description of the geology can be found in Appendix G of Appendix 7/1. A summary is provided below.

2.5.2 Regional Geology

Solid Geology

The key solid geology formations are:

- Triassic Mercia Mudstone: Coarse grained, conglomeratic marginal facies (aquifer) and distal mudstone facies (non aquifer);
- Carboniferous Limestone: A variable sequence of limestones, shales and sandstones. The most layered, shaley units are concentrated at the top and bottom of the sequence. The main limestones worked at the quarries comprise the Cornelly Oolite and Stormy Limestone (Cornelly and Grove) and the overlying Oxwich Head Limestone (Gaens quarry).

The mapped extent of these strata and associated cross sections from the BGS (2000) are shown on Figure 3.1 and 3.2 respectively in Appendix 7/1.

The Carboniferous Limestone which is worked by the quarries forms the main aquifer in the area, and is classified as a Major Aquifer by NRW for the purposes of groundwater protection. The Carboniferous Limestone forms the higher plateau around the quarries.

Other formations form minor aquifers (e.g. the blown sand deposits at Kenfig and the Triassic Mercia Mudstone Marginal Facies) or non-aquifers (e.g. the Mercia Mudstone (undifferentiated) and the estuarine clays and silts at Kenfig).

Superficial Geology

The superficial deposits in the study area are shown on Figure 3.3 of Appendix 7/1. The main units of significance at outcrop are:

- Blown sands: The dune fields at Kenfig and Merthyr Mawr comprise loose, fine-grained sand with shell debris.
- Estuarine clays and alluvium (organic rich clays and silts with beds of peat) underlies the blown sands at Kenfig. At Merthyr Mawr a thin 1-3 m thick clay layer underlies the Blown Sands.
- Till: Much of the area around Pyle is underlain by relatively impermeable Diamicton and gravelly, clayey sand.
- Glaciofluvial deposits. Predominantly sand and gravel forming a minor aquifer. This underlies the estuarine clays at Kenfig. In places this lies directly on the Triassic marginal facies or Carboniferous Limestone thus providing a potential pathway between the main aquifer system and groundwater in the superficial deposits.

2.5.3 Local Geology

Kenfig

The detailed review of the local geology presented in Appendix G of Appendix 7/1 concludes that the low permeability estuarine clays and alluvium is present throughout the main area in which the overlying Blown Sands are saturated.

Merthyr Mawr

Within the Merthry Mawr SAC, Blown Sand overlies Friar's Point Limestone over most of the area. In the west there is a small area of subcrop of Mercia Mudstone Marginal Facies and in the east, around Candlestone Stream, there is a small outcrop of Brofiscin Oolite Formation and Barry Harbour Limestone Formation. Beneath the Mean High Water line the outcrop is predominantly marine beach deposits of sand with some outcrop of limestone in the west. A strip of Tidal Flat Deposits follows the line of the River Ogmore.

2.6 Hydrology and Hydrogeology

2.6.1 Hydrology

The main surface water flows of interest relate to the two large springs in the area:

- The large, perennial springs at New Mill Farm have been identified as an important feature of the local hydrology and comprehensive flow measurements have been undertaken. The spring complex comprises a main spring (20 to 70 l/s, 1,700 to 6,000 m^3/d) sourced from underlying Triassic strata and numerous other smaller seeps and springs in this general area. The total gain in the reach around the springs is around 190 l/s (16,400 m^3/d) although some of this is derived from the surface water catchment of the reach.

- A flume and data logger have been installed by Lafarge-Tarmac on Burrows Well, the Carboniferous Limestone spring that rises in the middle of Merthyr Mawr dunes. The data show that the spring is ephemeral with flows up to 350 l/s (30,000 m^3/d) but more typically around 50 l/s (4,300 m^3/d).

In addition to these flows, there is some surface water flow in the dune slacks at Kenfig during high groundwater level conditions. However, this all recharges to the Blown Sands to the west rather than flowing to the coast.

The majority of the effective rainfall in the area discharges via groundwater to the sea in a way such that it cannot be measured. As a result, the water balance of the aquifer cannot be constrained by measured data, hence the need for a transient flow network model. Uncertainties in the water balance have been dealt with by sensitivity analysis on the flow network model, varying recharge within a range that is considered to be physically realistic (+/- 15%).

2.6.2 Hydrogeology

Groundwater levels have been monitored by T.S. Rees Limited in conjunction with Lafarge-Tarmac, the NRW and staff at the Nature Reserves at nearly 60 sites in the area over the last decade with some sites having up to 16 years of data. This forms an exceptional baseline for the assessment of the impacts of the quarries.

Two types of aquifer are present in the study area: porous medium aquifers, in which flow is distributed relatively evenly throughout the whole formation (e.g. the Blown Sands of the sand dune systems) and karstic aquifers in which flow occurs almost entirely through solution enhanced fissures or conduits (e.g. the Carboniferous Limestone and Triassic Marginal Facies).

Section 7.4.4 of the ES sets out the detailed hydrogeological background at the site and the results of the extensive assessment that has been undertaken.

2.7 Cultural Heritage

Until the latter half of the 20th century the land within the site was predominantly agricultural. Quarrying expanded into the site over a period of 20 years between the later 1960s and 1980s, eventually removing the majority of surface deposits down to bedrock with the exception of a strip of land along the south west boundary. The current quarry falls within a wider zone of mineral extraction to the east of South Cornelly.

Because of its topographic location surrounded by a wooded ridge, and in part also due to the rolling character of the surrounding countryside, Gaens is not readily visible from the surrounding landscape and does not currently form an appreciable visual component of the setting of any surrounding heritage assets.

The evidence for archaeological activity in the area suggests that local sites were favoured for settlement, subsistence and ritual/funerary activity from the Neolithic period onwards. South Cornelly has medieval origins, with strip fields surrounding the small settlement focussed around the Church of St Cornelius. Managed farmland does not appear to have extended up on to the ridge occupied by the quarry, however it is likely that the area later known as Whitecross Down was used as seasonal pasture.

Within the site there is no potential for surviving archaeological remains where quarrying has occurred.

3.0 PROPOSED DEVELOPMENT

3.1 Introduction

The operations at Gaens Quarry represent a convential approach to mineral extracton. The blasting of rock ensures an adequate supply of material that is then processed using mobile plant. The following section sets out how this process will ensure the effective and continuous extraction and processing of material over the life of operations.

The quarry has operated effectively on the basis of existing conditions for over 50 years, and the proposed continuation will be broadly in accordance with these practices, albeit under updated and modern operating conditions.

The quarry development scheme is depicted on plans which show the quarry development on a phased basis. The key focus of the current ROMP Review will be on the first fifteen years following which, based upon current legislative requirements, there will be a need for a Periodic ROMP Review which will consider the quarry development for the subsequent 15 years, any changes to the development scheme proposed at that time, and any revised conditions which are deemed to be appropriate at that time. It follows that environmental effects of the ongoing development post year 15 can be re-assessed as part of that process. However, the current submission has not sought to confine the development scheme or the impact assessment to the initial 15 year period. The submission includes a development scheme for the full quarry development, and the effects of that full development scheme have been assessed as part of the EIA and reported in this ES.

The submitted application drawings are as follows, with corresponding Figures 3-1 to 3-4 at the rear of this section:

- 3782/01: Existing Situation
- 3782/02: Phase 1
- 3782/03: Phase 2
- 3782/04: Phase 3
- 3782/05: Phase 4

In addition, Restoration Strategy Plans are submitted:

- M13.128b.D.012: Concept Restoration Strategy (Figure 3.5);
- M13.128b.D.011: Concept Restoration Strategy – Overview.

3.2 Working Scheme

In terms of future development the proposal will focus on the contined extraction from the eastern part of the remaining void, followed by extraction in a generally western direction. The final phase of extraction will be undertaken from the south-eastern extremity of the site.

Extraction will generally take place within the currently disturbed area, although the western extension includes a section of the currently wooded ridgeline that forms the southwestern boundary of the site. The development extends the quarry laterally to the permitted limit of extraction to a final face configuration that maximises the width of the quarry in order to allow deepening.

It will be observed from Drawing 3782/01 that operations have historically been undertaken from small areas outside of the permitted (red-line) boundary. In the case of the northern boundary this has included the creation of an access track. The southern boundary includes an “incursion” into the red-line boundary in the shape of an inverted “L”. This was previously the location of Pant Mawr Farmhouse. Historical operations have taken place within this area, including the deposition of material and limited extraction. For the avoidance of doubt, the current submission does not propose any extractive operations outwith the red-line boundary of the ROMP.

This operation will also involve the completaion of the removal of the majority of the large overburden/quarry waste tip on the southwestern boundary in the short to medium term (5-10 years). The main quarry floor to the east is currently at some 9m AOD, with deepening planned to reduce this to some -20m AOD. This will take place over the next 10-15 years. The plant site is currently located to the west of the quarry void on a wide bench at some 37m AOD and following completion of this first phase of operations, the quarry will then be extended to the northwest into the area currently occupied by the processing plant and water management lagoon. At this time (+15 years), it is expected that the processing facilities will be relocated within the main quarry void. Overburden and quarry waste from these operations will be used to partially infill the main worked out western void.

In terms of output and its implications for the remaining operational life of the Quarry, recent years have seen production at a steady 150,000 tonnes per annum. In the past, output has exceeded 200,000 tonnes. For the purposes of this submission, an average output of 150,000 tonnes per annum is assumed. Given an estimated reserve of some 8 million tonnes this assumes an operation period of some 53 years.

3.3 Quarry Development Scheme

3.3.1 Phase 1: 1 - 10 years: Drawing 3782/02

The initial phase of extraction will involve the deepening of the current working area within the eastern part of the site as shown on Drawing 3782/02.

Faces will be worked, by means of drilling and blasting to break up the rock mass, followed by loading into dump trucks by an excavator for transport to the primary crushing facility for onward processing.

The extraction will take place on a progressive basis to the extent of the working area shown on Drawing 3782/02. The limit of extaction will be defined by the extent of the historical working faces along the northern and eastern boundaries. During the latter part of this phase, the haul road shown on Drawing 3782/02 will be constructed. This will provide access to the void for the remainder of the working life of the quarry. The plant site will also be relocated during the latter part of this phase to the south of the water storage lagoon.

The final bench widths will be between 7.5m to 10m wide, depending on the assessment of individual rock faces and the risks of rock fall from these faces.

The extraction will take place on a progressive basis to the extent of the woking area shown on Drawing 3782/02.

The total extraction shown for this stage is approximately 1.5 million saleable tonnes.

3.3.2 Phase 2: 11-30 years: Drawing 3782/03

The second phase of the scheme will involve extraction to the south of phase 1 towards the southern boundary of the site. Using the in situ haul road, and as shown on Drawing 3782/03 Phase 2 will be accessed via the worked out Phase 1.

The stand-off will be maintained at 5m from the southern boundary in accordance with the original planning permission. The total extraction shown for this stage is approximately 3,000,000 saleable tonnes.

The plant site and water storage lagoon will be maintained in their identified locations for the duration of Phase 2.

3.3.3 Phase 3: 31-40 years: Drawing 3782/04

Phase 3, illustrated on 3782/04, involves the extraction of land within the south-western part of the quarry. The haul road will continue to service this phase which will be extracted to a similar depth of -20m AOD.

It is within this part of the Quarry that part of the Tree Preservation Order Ref: OBE No.06 is located. The original permission for this part of the site (ref:JPC 892/1209) was permitted in March 1948 and pre-dates the TPO allocation (1977).

The working scheme has therefore sought to retain as much of the TPO area as possible, and that outside of the redline boundary will not be impacted.

Drawing 3782/04 illustrates that the stand-off between the extraction area and the permitted boundary is 10m (as opposed to the 5m previously permitted by the 1948 permission). This will ensure the retention of a band of woodland along this boundary.

In order to achieve the extraction from Phase 3 and the creation of the extended haul road there will be a reconfiguration of water storage facilities. The existing lagoon will be reduced by some 40% (in terms of surface area) and a compensatory temporary sump (of a similar scale to that forfeited) will be created within the southern part of the previously worked out Phase 2.

In order to accommodate the extraction of Phase 3, the plant site will be relocated to the eastern part of the site adjacent to the haul road.

The total extraction shown for this stage is approximately 1,500,000 saleable tonnes.

3.3.4 Phase 4: 41 – 53 years: Drawing 3782/05.

The final stage of extraction covering approximately 15 years of development comprises deepening the eastern extremity of the quarry to -20m AOD. A 10m wide strip of land will be sterilised along the eastern boundary of the site to ensure an effective stand-off from the adjacent operations.

The layout of the processing plant will be reconfigured at this stage to facilitate access to the extraction area.

In total, this stage represents extraction of approximately 2.0 million tonnes.

3.4 Processing Plant

The processing operations at Gaens Quarry rely on the use of a mobile crushing and screening plant located within the quarry void, in relative proximity to the operational quarry area as it progresses. The location of the plant site at each stage is indicated on the phasing drawings.

The plant will continued to be regulated by a PPC Permit issued under the provisions of the Pollution Prevention and Contol Act 1999, which imposes detailed requirements relating to air quality emissions and the monitoring and mitigation of emissions. The controls which are imposed via the Permit have been taken into consideration as part of the Air Quality study (ref ES Chapter 10.0), and the noise emissions from a typical mobile crushing and screening plant have been assumed for the purposes of the noise study (ref ES Chapter 8.0).

A copy of the Permit is produced as Appendix 3/1. The Authorisation sets out some 50 detailed conditions relating to emission limits, emission controls, fuel oil controls; monitoring; record keeping; sampling provision, notifications of defined events; general materials handling and specific requirements for storage silos, hoppers and screens; materials handling for mobile crushing and screening plant; transport and loading; roadways, chimney vents and process exhausts, staff training and supervision, and general good practice maintenance and use of plant and equipment.

3.5 Hours of Operation

The hours of operation at a quarry are required to address not only the times during which extraction takes place, but also, in accordance with MTAN1, other operational matters, including blasting. The proposed hours of working against which noise matters have been assessed are:

a) Except in emergencies* to maintain safe quarry working (which shall be notified to the MPA as soon as practicable or unless the MPA has agreed otherwise in writing, the following shall apply:

    a. No quarry operations, other than water pumping, the servicing/maintenance of plant, and environmental monitoring, shall be carried out at the site except between the following times:

        i. 0700 – 1900 hours Monday to Friday; and

        ii. 0700 – 1300 hours Saturday.

    b. The servicing, maintenance and testing of plant shall only be defined as instances where the operation has reasonable cause for preventing injury to persons or serious damage to property.

    c. For the avoidance of doubt, emergencies shall be defined as instances where the operation has reasonable cause for preventing injury to persons or serious damage to property.

    d. No operations other than environmental monitoring and water pumping at the site shall take place on Sundays or public/bank holidays.

    e. No operations for the formation and subsequent removal of material from bunds/soil storage areas shall be carried out at the site except between the following times:

i. 0800 – 1800 hours Monday to Friday; and

ii. 0800 – 1300 hours on Saturdays.

b) All blasting shall be carried out in accordance with a scheme to be submitted to and approved by the MPA. Such a scheme shall include:

a. The restriction of blasting only between the hours of 1000 and 1600 hours (Monday to Fridays) and not at all on Saturdays, Sundays or statutory public/bank holidays;

b. The prevention of secondary blasting except as may be agreed with the MPA in writing;

c. A system of warning sirens to be sounded prior to the commencement of blasting operations;

d. The carrying out of blasting operations so that the ground vibration as measured in any one of three orthogonal planes at, or near, the foundations of any vibration sensitive building or residential promises shall not exceed 80.00 mm per second (ppv). Within the design limit every effort shall be made to ensure that the ground vibration for at least 95% of all blasts over a period of 20 consecutive weeks does not exceed a ppv of 6mm/sec.

e. The methods to be used to minimise the effects of air blast overpressure arising from blasting, having regard to blast design, methods of initiation and the weather conditions prevailing at the time of teh blast.

f. The details of blast monitoring including the location and frequency of monitoring; the type of monitoring equipment to be used; and the manner in which the results will be recorded and made available for inspection by the MPA.

3.6 Traffic Movements

In the context of transport and highways issues, the key features of the development will continue in accordance with current practices in terms of output (150,000 tonnes per annum), operating hours, and the use of the well-established and permitted access road.

The types of HGVs serving the site will be consistent with current and historic operations, which have been safely accommodated on the local highway network. The majority of HGVs except for the occasional vehicle making a local delivery to satisfy demand in the immediate vicinity of the site would travel along the A4229 to/from Junction 37 of the M4 Motorway, in accordance with existing movements to/from the site.

In effect, the proposed development will result in no change to the network when compared with the existing planning permission which is subject to the review process.

Based on the existing and recent activities at the site, the extraction and distribution of 150,000 tonnes of material per annum will result in an average of 62 HGV movements per day (31 in/31 out) based on 275 working days per annum and an average payload of 18 tonnes per vehicle. This is generally consistent with the range observed during the period of the surveys undertaken as part of this review.

All traffic travels along Porthcawl Road, with almost all vehicles heading to/from the north of the site access, thereby restricting the use of local roads to a length of 150m between the site and the A4229 principal road network beyond.

The majority of movements to/from the site then travel along the A4229 to the north to/from Junction 37 of the M4 Motorway.

The implication of the proposed output on the local and wider highway network is considered in detail at Chapter 9 below.

3.7 Water Management

Water arising from the quarrying operations is stored on site within the lagoon in the north-western part of the ROMP void.

Details of the future water management proposals are set out in the Water Management Plan produced as Appendix 7/5 (within Volume 2C), and described further in Section 7.10 of the ES.

3.8 Alternatives

In undertaking an EIA it is customary to consider the principal alternatives to the development, although such an exercise is not mandatory in all cases. This assists the determining authority in their consideration of whether planning permission should be granted. If the principle is acceptable then it provides a further opportunity to review the alternative means of undertaking the development.

The starting point in the consideration of the ROMP Review application is the established fact that planning permission exists for the extraction of minerals from the ROMP site. The principle of the development has therefore been established by virtue of those extant planning permissions. The purpose of the current exercise is to allow the EIA to inform the process of updating the planning conditions which should regulate and control the on-going quarrying operation.

In those circumstances, and in the context of the conclusions of this EIA it has not been deemed appropriate or necessary to undertake a detailed analysis of alternatives to a continuation of quarrying at Gaens. This is recognised in the Scoping Direction which notes that "*as the current application is for a review of conditions, detailed consideration of alternative sites and materials is not appropriate*" (ref para 23).

The Scoping Direction also notes that there are other options for the development of the quarry including quarrying to shallower depths (ref para 23). The principal 'alternative' in terms of a quarry development scheme is thus to deepen the quarry to shallower depths than the -20 metres AOD confirmed in the submitted quarry development plans.

The environmental effects of quarrying to -20 metres AOD have been considered as part of the studies of hydrogeological impact and indirect ecological effects. Based upon the content of the hydrogeological impact assessment, no significant adverse effects have been predicted to arise from quarrying to those depths. Alternatives to this proposed depth are therefore not considered further.

3.9 Restoration Strategy

3.9.1 Introduction

Paragraphs 21 and 22 of the Scoping Direction (Appendix 1/1) requires that:

> *21. The ES should include an assessment of the restoration proposals for the site and its proposed after-use, proposals for progressive restoration of the site, and proposals for the integration of the site into the surrounding land in conjunction with other quarries nearby. This includes consideration of the overburden mound in the south east corner and the steepness of faces. The restoration strategy must address these latter matters as well as more general ones.*
>
> *22. This is a potentially complex scenario and the final restoration and aftercare for Gaens quarry, in combination with Grove and Cornelly quarries, will need to be addressed.*

This section highlights the aims, objectives and restoration strategy for Gaens Quarry (including the western IDO area), as well as making reference to the site in the wider context of the overall restoration strategy for the whole quarrying complex that also includes both the Cornelly and Grove sites.

The Concept Restoration Scheme for Gaens Quarry is illustrated on Drawing Nos. M13.128b.D.011 and M13.128b.D.012. These drawings show the restoration proposals for Gaens in conjunction with the proposed restoration schemes for Cornelly and Grove Quarries, as well as in context to the surrounding landscape based on up-to-date aerial photography (July 2013).

The Concept for the Restoration of the Site is based on the anticipated physical form of the quarry upon reaching the final extent of quarrying as illustrated on Drawing No 3782/05, together with mitigation and enhancement features. These include:

- Hedgerow/woodland strengthening and enhancement in the short and medium terms along the northern and southern boundaries of the site to provide a wildlife corridor to link together existing isolated tree clumps and vegetation blocks around and/or adjacent to the quarry, as well as in the wider context of Grove, Pant Mawr, Cornelly and Stormy Down Quarries.
- Creation of species rich calcareous grassland in the medium and long term on quarry waste tips within the western quarry void.
- Revegetation of overburden slopes, quarry waste tips and faces/benches in the medium and long term that are expected to remain following flooding of the quarry void to create a mosaic of woodland/scrub/grassland habitats around the periphery of the site.
- Retention of rocky outcrops and creation of scree slopes in the medium and long terms that could be advantageous for the creation of habitats suitable to encourage colonisation by protected species.
- Creation of wetland and marginal habitats in the long term around the edges of the flooded quarry void to encourage the establishment of habitats suitable to encourage colonisation by protected species.

3.9.2 Afteruse Strategy

The main aims and objectives of the Restoration Strategy for Gaens Quarry is to:

- Maximise mineral resources whilst preventing the quarry during its operational life from adversely affecting the local landscape setting and the general visual amenity of the area viewed either by local residents, visitors/tourists or transient receptors. In particular the landscape setting of Newton Down, Porthcawl Hinterland, Kenfig Sands and Burrows Visual and Sensory Aspects, plus the Merthyr Mawr, Kenfig and Margam Burrows Landscape of Outstanding Historic Interest, as well as Kenfig Burrows, Laleston and the Porthcawl Coast SLAs.
- To integrate and assimilate the restored land within its local landscape character and maximise the potential of the quarry in the longer term to become a distinctive feature that positively contributes to the landscape setting and visual amenity of the Newton Down and Porthcawl coastal region and help to create a distinctive sense of place for the area.
- Maximise the potential of the quarry to provide a range of bio-diverse habitats both in the short and longer terms and to meet local BAP targets.
- To increase the defined public access within the Site, including viewing areas and information/interpretation boards and link these pathways with the surrounding public footpath network.

3.9.3 Progressive restoration

The Main Aims of the Restoration Strategy for Gaens Quarry is to be achieved by instigating a programme of progressive restoration, including:

- Deciduous tree and hedge planting along the northern, western and southern boundaries of the site early within the development to link together the various isolated woodland blocks and naturally regenerated wooded slopes. This programme to help strengthen the wooded characteristics of the surrounding scarp slopes that separate the relatively intensely agricultural managed upland areas from the coastal plain and provide a mature wooded screen to help prevent quarry faces and other ancillary activities from generating adverse impacts on the localities landscape and visual amenity.
- The careful design of the phased development of the quarry during its operational life to prevent quarry faces and ancillary operations from generating significant adverse impacts on the localities landscape and visual amenity and retain as many areas of natural regeneration as possible.
- This operational sequencing also designed to allow the instigation of a programme of progressive restoration to minimise the amount of disturbed ground within the Site and allow the early development of a diverse range of habitats by:
    - Creating a strong, species rich intact hedgerow/woodland belt along the northern and western boundary of the site as early within the development as possible to remove landscape and visual impacts associated with quarrying and ancillary activities and enhance habitat diversification.
    - Creating areas of species rich calcareous grassland in the medium and long term on quarry waste tips within the western quarry (IDO) void.
    - Restoring upper benches and faces as early within the development as possible.
    - Preserve certain geological features including remnant quarry faces, areas of faulting and joints and bedding plains to maximise the potential for the quarry to become a RIGS (Regionally Important Geological Site)

3.9.4 Restoration proposals

In relation to Gaens Quarry a breakdown of landuses and opportunities for informal public recreation that comprise the Concept Restoration Scheme as illustrated on Drawing No M13.128b.D.012 including management areas are set out in Table 3.1 below.

Table 3-1 Existing and Proposed Landuse Types Following Final Restoration

LANDUSE TYPE	AREA
Existing woodland/scrub vegetation (retained) - excluding enhancement areas	0.47ha
New and/or enhanced woodland	3.62ha
Species Rich Calcareous Grassland	1.97ha
Calcareous grassland/scrub woodland/natural regeneration mosaic	1.7ha
Bench planting/scree slopes /natural regeneration	2.58ha
Grassland (interim restoration/possible future leisure/industrial use	0.31ha
Boggy / wet ground / Aquatic Marginals	0.33ha
Open Water Features	7.29ha
Pathways internal to the site	785lin.m
TOTAL	**18.27ha**

The detailed restoration scheme for the site comprises a diverse range of landscape and wildlife habitats which are listed below by restoration type. There are a total of four main restoration types included within the scheme.

These are:

- Hedgerows.
- Deciduous Dry and Damp Woodland.
- Calcareous Grassland.
- Wetland and Marginal Vegetation.

Hedgerows

As part of the proposed mitigation measures, as well as forming an integral part of the long term and progressive restoration and landscape enhancement of the quarry, hedgerow creation and infill planting is included within the restoration strategy for the Quarry. Species to include the following as listed within Table 3.2 below:

Table 3-2 Proposed Hedgerow Species List

Species	% Mix
Crataegus monogyna – Hawthorn	35
Acer campestre – Field Maple	5
Prunus spinosa – Blackthorn	10
Corylus avellana – Hazel	10
Cornus sanguinea – Dogwood	5
Fraxinus excelsior – Ash*	10
Rosa canina – Dog Rose	5
Viburnum lantana – Wayfaring Tree	10
Quercus robur – Oak (also as individual tree species)	10
TOTAL	**100**

*Due to Ash tree dieback caused by the Chalara fraxinea fungus at present this species is not being included within any planting mix for the foreseeable future. However, due to the long term nature of these proposals, this species has at present been included within the long term plans for the site, being such an important plant within the ecosystem of the British Isles.

New hedgerows are to be planted as a double staggered row (450mm between rows) with 6 N° plants per linear metre. Stock to be 'T' Notch planted and protected by 450mm rabbit spirals secured to 600mm cane by 1 N° tree tie.

Where existing hedgerows are to be beaten up/strengthened, 3 No plants per linear metre have been proposed. The plants are to be ‘T Notch’ planted and protected by 1 No 450mm rabbit spiral guards secured to 1 No 600mm cane by 1 No plastic tie.

Individual trees to be pit planted within the line of the hedgerow in pits 300mm x 300mm x 300mm and backfilled with 50% original material and 50% Peat Free Compost, plus slow release fertiliser. Trees to be protected by a 600mm tree/shrub shelter secured to 750x20mm square softwood stake by 2No plastic tree ties.

All stock to be supplied as Cell grown plants between 40-60cm in height.

Deciduous Woodland

As part of the proposed mitigation measures, as well as forming an integral part of the long term and progressive restoration and landscape enhancement of the quarry, extensive areas of tree and shrub planting are proposed, both within the main quarry itself including bench restoration planting as well as around the boundary. The woodland blocks are mainly ‘dry’ in nature by woodland trees are also proposed adjacent to open water bodies, so a mix has also been included that include ‘wet’ species. The proposed core species mix to include the following as listed within Table 3.3 below:

Table 3-3 Proposed Woodland Species Mix

Species	% Mix
DRY WOODLAND	
Quercus robur – Oak	35
Fraxinus excelsior – Ash*	15
Crataegus monogyna – Hawthorn	10
Acer campestre – Field Maple	10
Malus sylvestris – Crab Apple	5
Prunus avuim – Wild Cherry	5
Rosa canina – Dog Rose	5
Viburnum lantana – Wayfaring Tree	5
Corylus avellana – Hazel	10
TOTAL	**100**
WET WOODLAND	
Alnus glutinosa – Alder	35
Fraxinus excelsior – Ash*	15
Betula pubescens – Downy Birch	10
Populus nigra – Poplar	10
Salix alba – White Willow	5
Salix fragillis – Crack Willow	5
Salix caprea – Goat Willow	5
Salix cinerea – Grey Willow	5
Salix viminalis - Osier	10
TOTAL	**100**

All stock to be supplied as Cell grown plants between 40-60cm in height planted at 2m centres in single species groups of 5-7 plants. Shrub species to be concentrated to the edges of the planting blocks. All stock to be planted in 200 x 200mm pits backfilled with 50% original soil and 50% non peat based tree planting compost incorporating 20 grams of a suitable slow release fertiliser. Trees to be protected by a 600mm tree/shrub shelter secured to 750x20mm square softwood stake by 2No plastic tree ties.

These species, or combinations, therefore would be used as the basis of planting within the quarry. To create appropriate habitat for Dormice or other protected species, the planting mix is to have a relatively high percentage of nut bearing species such as hazel norm together with berried species such as guelder rose, dogwood and hawthorn.

Other species including Pedunculate Oak (Quercus robur), Silver Birch (Betula pendula), Goat Willow (Salix caprea) and Alder (Alnus glutinosa) may also be planted within the progressive restoration of the Site.

Certain areas may be left to naturally regenerate and/or hydroseeded with tree and shrub species to encourage initial vegetation growth. Natural regeneration of woodland will also be supplemented by direct planting of trees and shrubs.

Calcareous Grassland

In general terms, wherever possible, species rich calcareous grassland areas will either be left bare with 'top dressing' material left as the main growing medium i.e. topsoil, subsoil, overburden, scalpings and/or waste rock.

Certain areas may be hydroseeded with grass and/or tree and shrub species to rapidly encourage vegetation growth. Natural regeneration of woodland will also be supplemented by direct planting of trees and shrubs.

Where more formalised grassland habitat creation is proposed the following species mix as listed within Table 3.4 and Table 3.5 to be adopted. Seed is to be broadcast sown (at a rate of 3 – 5 g/m²) and chain harrowed into the surface if appropriate.

Table 3-4 Proposed Calcareous Grassland Species Mix – Wildflowers

Species	% Mix
WILD FLOWERS	
Achillea millefolium - Yarrow	0.5
Anthyllis vulneraria - Kidney Vetch	1.0
Centaurea nigra - Common Knapweed	1.0
Centaurea scabiosa - Greater Knapweed	2.0
Daucus carota - Wild Carrot	0.5
Galium verum - Lady's Bedstraw	1.0
Knautia arvensis - Field Scabious	2.0
Leontodon hispidus - Rough Hawkbit	0.5
Leucanthemum vulgare - Oxeye Daisy	2.0
Lotus corniculatus - Birdsfoot Trefoil	2.0
Onobrychis viciifolia - Sainfoin	1.0
Plantago lanceolata - Ribwort Plantain	0.5
Poterium sanguisorba - Salad Burnet	2.0
Primula veris - Cowslip	1.5
Ranunculus acris - Meadow Buttercup	1.0
Scabiosa columbaria - Small Scabious	1.5
TOTAL	**20**

Table 3-5 Proposed Calcareous Grassland Species Mix – Grasses

Species	% Mix
GRASSES	
Briza media - Quaking Grass	2.4
Cynosurus cristatus - Crested Dogstail	32
Festuca ovina - Sheep's Fescue	22
Festuca rubra - Slender-creeping Red-fescue	16
Koeleria macrantha - Crested Hair-grass	1.2
Phleum bertolonii - Smaller Cat's-tail	6

Trisetum flavescens - Yellow Oat-grass	0.4
TOTAL	**80**

This species rich mixture is suitable for sowing onto thin lime-rich soils of low fertility and with a significant limestone content. Sowing directly onto exposed limestone is likely to produce the most effective long term results, but establishment will be slower than on more well developed soils.

Wetland and Marginal Aquatic Areas

Wetland and marginal/emergent species are to be planted within areas that are accessible either following flooding of the main quarry void following completion of tipping of quarrying operations.

Species to include a calcareous grassland meadow mixture similar to as specified above, but with wildflowers more suitable for pond edges as listed below in Table 3.6.

Table 3-6 Proposed Emergent Wildflower Mix

Species	**% Mix**
WILD FLOWERS	
Achillea ptarmica - Sneezewort	5
Angelica sylvestris - Wild Angelica	10
Caltha palustris - Marsh Marigold	1
Eupatorium cannabinum - Hemp Agrimony	2.5
Filipendula ulmaria - Meadowsweet	13
Geum rivale - Water Avens	5
Iris pseudacorus - Yellow Iris	20
Lotus pedunculatus Greater Birdsfoot Trefoil	5
Lycopus europaeus - Gypsywort	5
Lythrum salicaria - Purple Loosestrife	2.5
Ranunculus acris - Meadow Buttercup	12.5
Scrophularia auriculata -Water Figwort	2.5
Silene flos-cuculi - Ragged Robin	7.5
Succisa pratensis - Devil's-bit Scabious	1
Vicia cracca -Tufted Vetch	7.5
TOTAL	**100**

3.9.5 Restoration Aftercare Management

All areas either within the confines of the Site that are to be managed for conservation afteruses will be subject to a detailed Aftercare Management Programme. Due to the nature and timescales associated with the Site, this programme will continue throughout the operational life of the quarry plus a further 5 years following final cessation of mineral extraction. This Aftercare Programme will cover each of the habitat types identified as either existing or to be created during the life of the development or following cessation of mineral extraction. In addition maintenance schedules have also been included for other secondary restoration types such as surface water drainage ditches, footpaths, disabled access, vehicular access and car parking, fencing., gates and styles and information areas/signage.

The programme will allow for annual site meetings between the developer, landowners, the local planning authority and/or other statutory or non-statutory bodies, as agreed, to monitor the establishment of the various habitats to be managed. The programme will also provide a detailed breakdown of additional and/or remedial works required on an annual basis to ensure the long term survival of these areas.

A Strategic Aftercare Plan is provided as set out in Table 3.7 below.

Table 3-7 Strategic Aftercare Plan

Habitat Types	Schedule of Typical Maintenance Works
Woodland Blocks	During first 5 years maintenance works will include the making good of any damage or defects, mulching to both retain soil moisture and warmth and to control competition from ground vegetation, light pruning and removal and/or loosening of ties, stakes and other tree protection measures, as well as removal of pernicious weeds and/or invasive plants. Subsequent visits between years 5-15 will include removal of ties, stakes and other tree protection measures as well as removal of pernicious weeds and/or invasive plants. Woodland management after some 15-20 years to include selective thinning by up to 25% to encourage development of individual species, to encourage natural regeneration and to encourage development of both the understory and field layer. Subsequent woodland management techniques will include removal of dead branches, crown thinning, crown uplifting, crown reduction etc. All tree works to be in line with recommendations as contained within BS 3998:2010 Tree work. Some form of vermin control may also be necessary throughout the management period.
Individual Trees	During first 5 years maintenance works will include the making good of any damage or defects, mulching to both retain soil moisture and warmth and to control competition from ground vegetation, light pruning and removal and/or loosening of ties, stakes and other tree protection measures as well as removal of pernicious weeds and/or invasive plants. Subsequent visits between years 5-15 will include removal of ties, stakes and other tree protection measures as well as removal of pernicious weeds and/or invasive plants. Subsequent management techniques will include removal of dead branches, crown thinning, crown uplifting, crown reduction etc. All tree works to be in line with recommendations as contained within BS 3998:2010 Tree work.

Habitat Types	Schedule of Typical Maintenance Works
Hedgerows	During first 5 years maintenance works will include the making good of any damage or defects, mulching to both retain soil moisture and warmth and to control competition from ground vegetation, light pruning and removal and/or loosening of ties, stakes and other tree protection measures as well as removal of pernicious weeds and/or invasive plants. Subsequent visits between years 5-15 will include removal of ties, stakes and other tree protection measures as well as removal of pernicious weeds and/or invasive plants and possible infill planting of gaps that may develop during the maintenance period. Hedgerow management will comprise regular light trimming throughout the establishment period to initially thicken, with a coppicing cutting cycle of once every three years for the remainder of the maintenance period. Pollarding techniques will be used to encourage the development of individual hedgerow trees. Trees to be regularly, lightly trimmed throughout the establishment period with on-going annual pollarding assessment. Subsequent visits (between hedge coppicing) will include removal of pernicious weeds and/or invasive plants and possible infill planting of gaps that may develop during the maintenance period. All tree works to be in line with recommendations as contained within BS 3998:2010 Tree work. Some form of vermin control may also be necessary throughout the management period.
Area of Natural Regeneration	During first 5 years maintenance works will include removal of pernicious weeds and/or invasive plants to encourage natural regeneration. Subsequent visits will include removal of pernicious weeds and/or invasive plants to encourage development of both the understorey and field layers where woodland is establishing. Management after some 15-20 years will include selective thinning where woodland is establishing to encourage development of individual species, to continue to encourage natural regeneration and to encourage development of both the understory and field layer. Where glades are naturally establishing removal of woody species will also be required. Subsequent management techniques will include removal of dead branches, crown thinning, crown uplifting, crown reduction etc. All tree works to be in line with recommendations as contained within BS 3998:2010 Tree work. Some form of vermin control may also be necessary throughout the management period.
Calcareous Grassland	Maintenance works throughout the management period will include light grazing for limited periods to both encourage the development of the grass sward; to encourage seed head production of wild grasses/flowers and act as natural weed control. Grazing by cattle is to be limited to the months of July to March to allow for flowering and setting of seed to take place. A hardier breed of cattle would be preferable which are more likely to provide variation within the grassland structure. Stock density of 1 cow per hectare. Husbandry will be the responsibility of the owner of the stock. Subsequent visits will include the need to re-cultivate and reseed small areas that have become worn or by animal damage (i.e. rabbits). Some form of vermin control as well as spot treatment of noxious weeds will also be necessary throughout the management period.
Woodland Glades	Maintenance works throughout the management period will include removal of invasive plants to prevent natural regeneration, keep areas open and encourage development of the field layer. Some form of vermin control as well as spot treatment of noxious weeds will also be necessary throughout the management period.

Habitat Types	Schedule of Typical Maintenance Works
Ponds and Wetland Areas	Maintenance works throughout the management period will include removal of invasive plants to prevent natural regeneration, keep water areas open whilst encouraging the development of the marginal areas. Some form of vermin control as well as spot treatment/removal of noxious pondweeds will also be necessary throughout the management period.
Surface Water Drainage	Maintenance works throughout the management period will include undertaking general ditch maintenance and/or clearing blockages within the ditches or associated with culverts and/or headwalls, sluices and/or vermin grills. Some form of vermin control as well as spot treatment/removal of noxious pondweeds will also be necessary throughout the management period.
Footpaths	Maintenance works throughout the management period will include removal of pernicious weeds and/or invasive plants to prevent natural regeneration and keep the route of the footpath/bridleway open. Any furniture, signage and drains to be maintained throughout the management period as detailed elsewhere within this schedule. Hard surfacing constructed as part of the bridleway upgrade will be maintained weed free and any erosion or gullying occurring to be made good if and when necessary throughout the management period. Throughout the management period, where a grassed area has become worn, or erosion/gullying occur due to excessive wear it will be necessary to re-cultivate and reseed these areas.
Permissive Disabled Access Trail (if appropriate)	Maintenance works throughout the management period will include removal of pernicious weeds and/or invasive plants to prevent natural regeneration and keep the route of the Disabled Access Trail open. Note: It may be necessary, dependant on final ground conditions along the route, areas of steeper gradient/rest areas etc. to provide areas of hard surfacing (hoggin) and additional furniture (handrails, signage, gates, ramps, drainage etc.) in line with recommendations as contained within the Disability Discrimination Act 1995. Furniture, signage, edging and drains will be maintained throughout the management period as detailed elsewhere within this schedule. Hard surfacing constructed as part of the Disabled Access Trail will be maintained weed free and any erosion or gullying occurring will be made good if and when necessary throughout the management period. In any event, throughout the management period, where a grassed area has become worn, or erosion/gullying occur due to excessive wear it will be necessary to re-cultivate and reseed these areas.
Informal Woodland Pathways	Maintenance works throughout the management period will include removal of invasive plants to prevent natural regeneration and keep the route of the Informal Woodland Pathways open. Throughout the management period where grassed areas have become worn, or erosion/gullying occurs due to excessive wear it will be necessary to re-cultivate and reseed these areas. Some form of vermin control as well as spot treatment of noxious weeds will be necessary throughout the management period.
Vehicle Access and Car Parking	Typical maintenance works will include making good any damage to all hard surfaced areas and peripheral areas to be maintained weed free and any erosion or gullying occurring to be made good when necessary throughout the management period. Fencing, furniture, signage etc. will be maintained throughout the management period as detailed elsewhere within this schedule.

Habitat Types	Schedule of Typical Maintenance Works
Fencing	Maintenance works will include making good any damage defects or rot to timber posts/rails, metalwork or line wires/netting as necessary due to wear and tear and/or vandalism throughout the management period. Life expectancy of the fencing is dependent on the type of material used in the construction, wear and tear and vandalism. It will be necessary to replace the fencing at least three to four times during the management period. Fencing which secures animals will require inspection several times a year.
Gates	Maintenance works will include making good any damage defects or rot to timber posts/rails, metalwork as necessary due to wear and tear and/or vandalism throughout the management period. Life expectancy of the gates is dependent on the type of material used in the construction, wear and tear and vandalism. It will be necessary to replace the gates at least three to four times during the management period.
Stiles	Maintenance works will include making good any damage defects or rot to timber posts/rails, metalwork as necessary due to wear and tear and/or vandalism throughout the management period. Life expectancy of the stiles is dependent on the type of material used in the construction, wear and tear and vandalism. It will be necessary to replace the stiles at least three to four times during the management period.
Signage, Interpretation Boards and Parkland Furniture	Maintenance works will include making good any damage defects or rot to any timber, metalwork or other materials used in the construction of the benches, signage posts, hand rails, ramps, edging, interpretation boards as necessary due to wear and tear and/or vandalism throughout the management period. Life expectancy of the above structures is dependent on the type of material used in the construction, wear and tear and vandalism. It will be necessary to replace these structures at least three to four times during the management period.

As the quarry develops and landscaping and restoration works progress, a Management Programme will also be set up to monitor the progression of the quarry and to identify areas where interim landscaping or final restoration measures can be implemented. A programme will also be established to monitor the development of both existing and proposed areas of woodland and grassland. These programmes will be informed by the use of a detailed 5 year quarry development plan that would be drawn up as part of the requirements of the Mines and Quarries Act.

Figure 3-1 Phase 1: 1 – 10 years

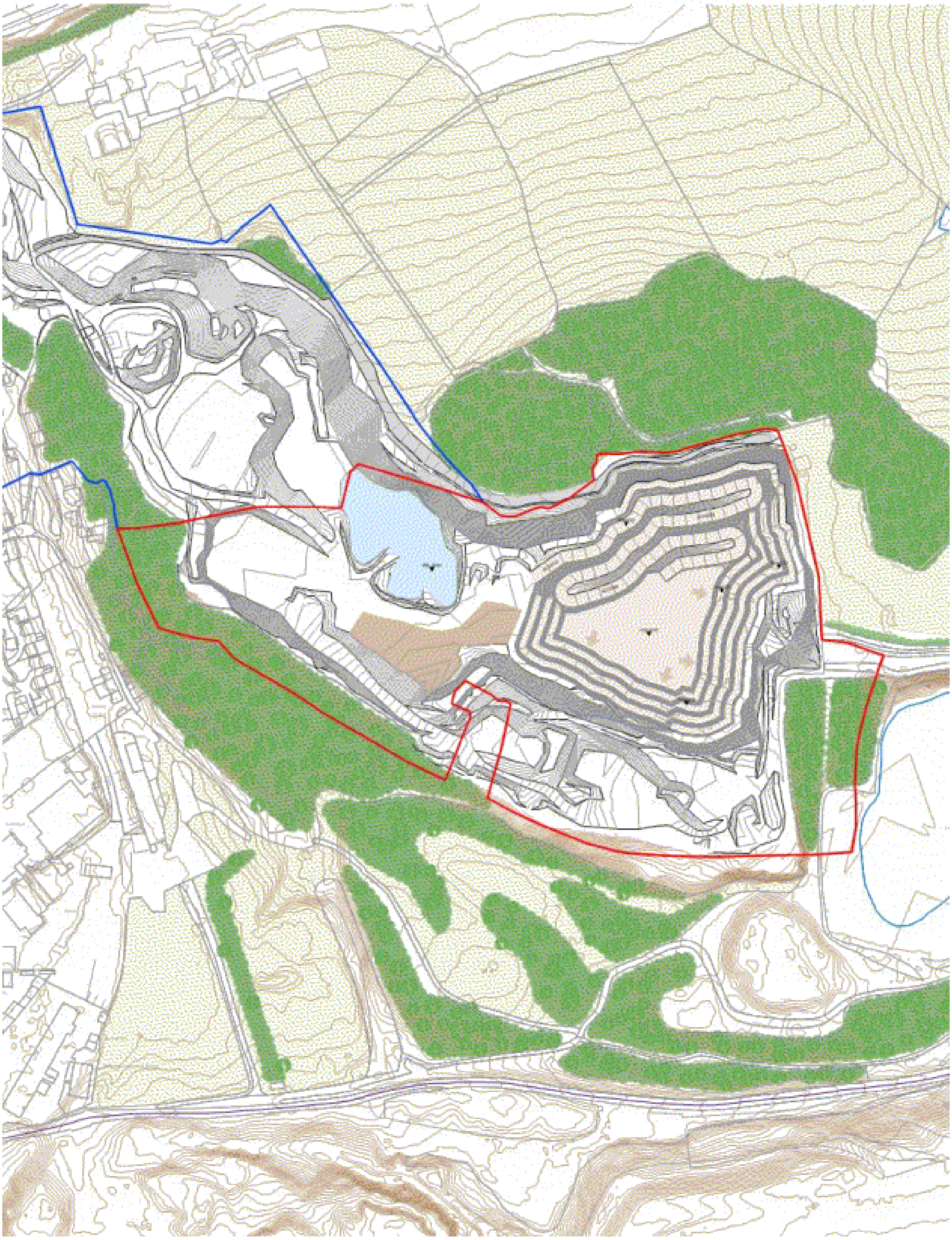


Figure 3-2 Phase 2: 11 – 30 years

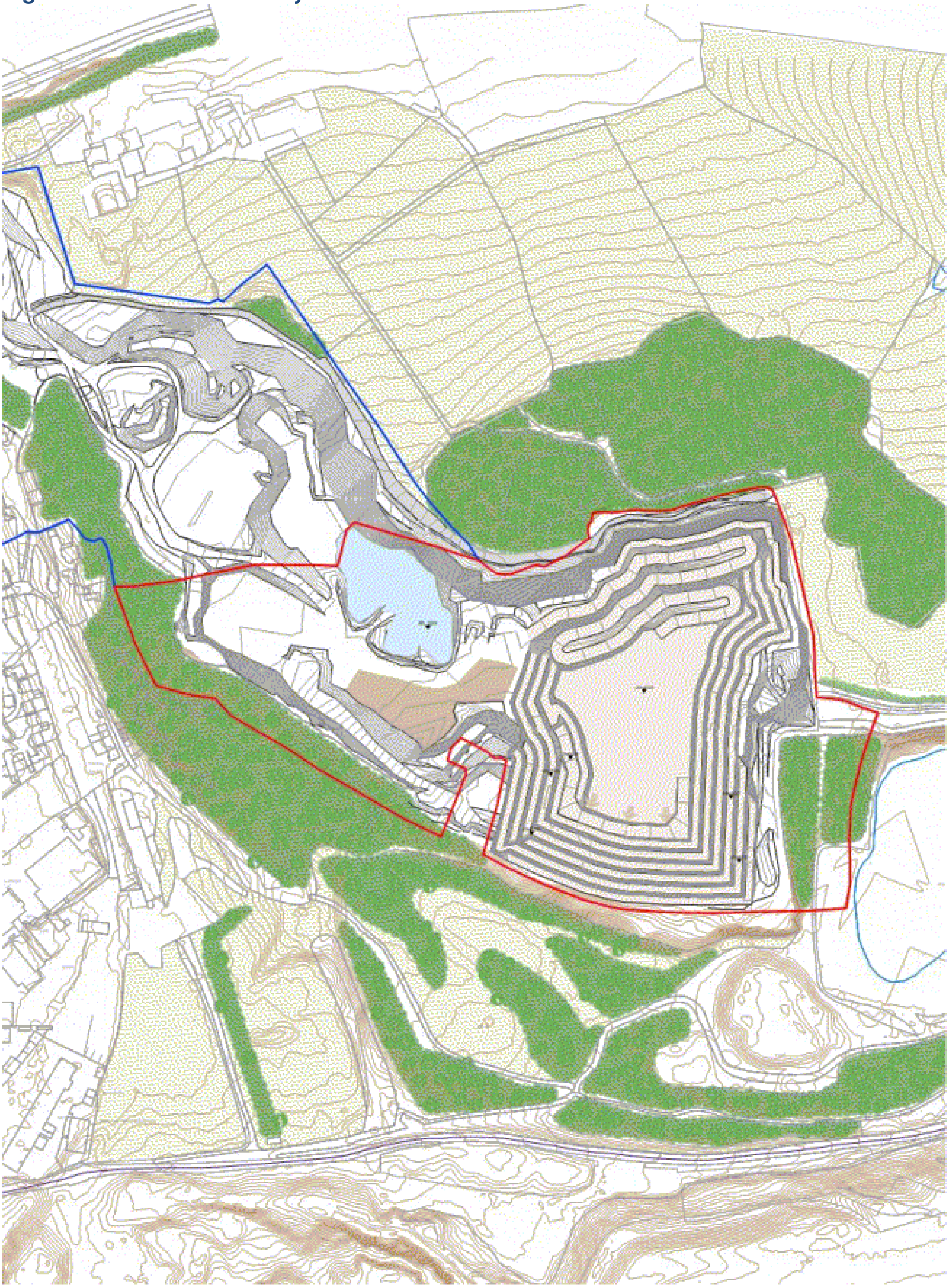


Figure 3-3 Stage 3: 31 – 40 years

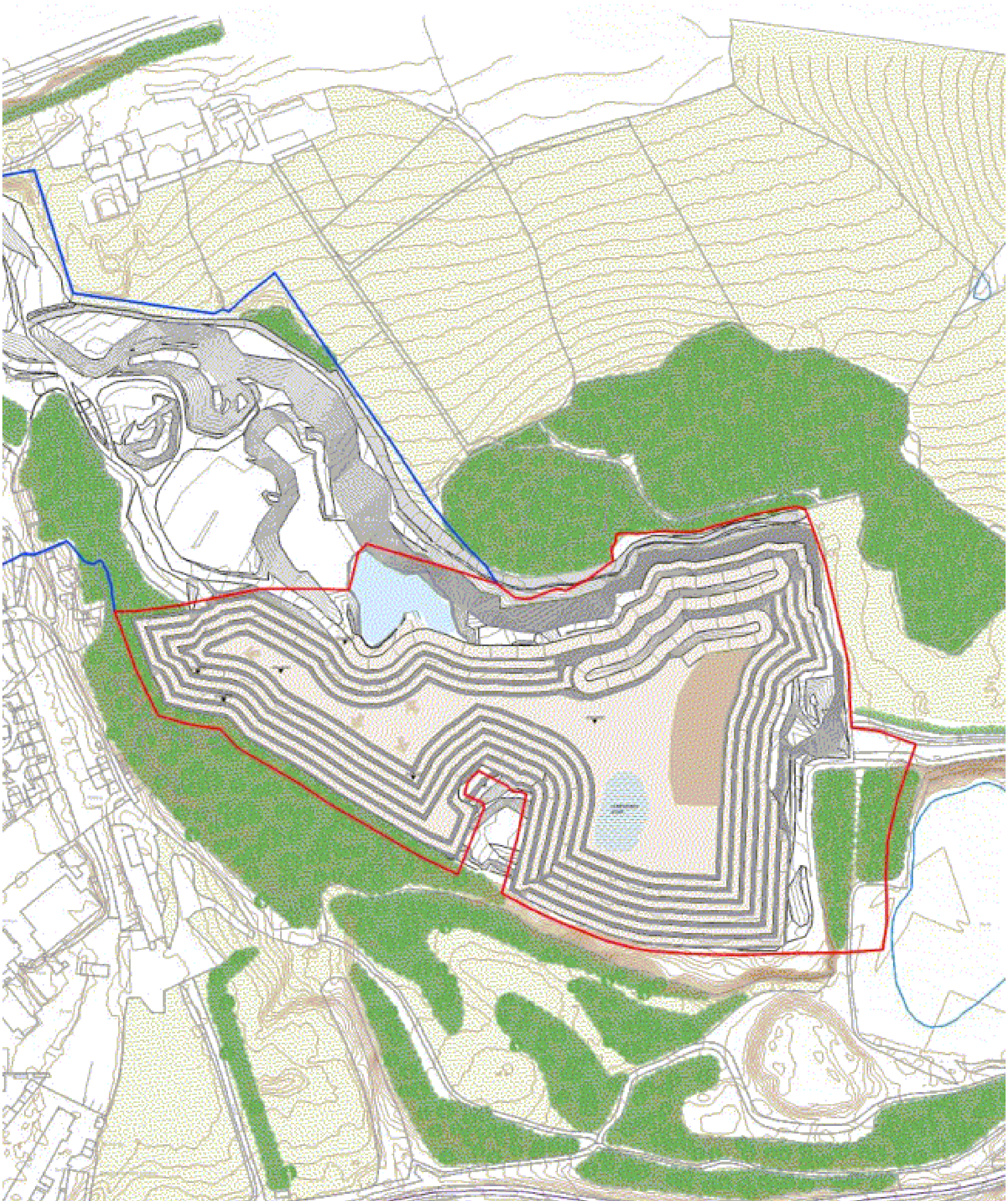


Figure 3-4 Phase 4: 41 – 53 years

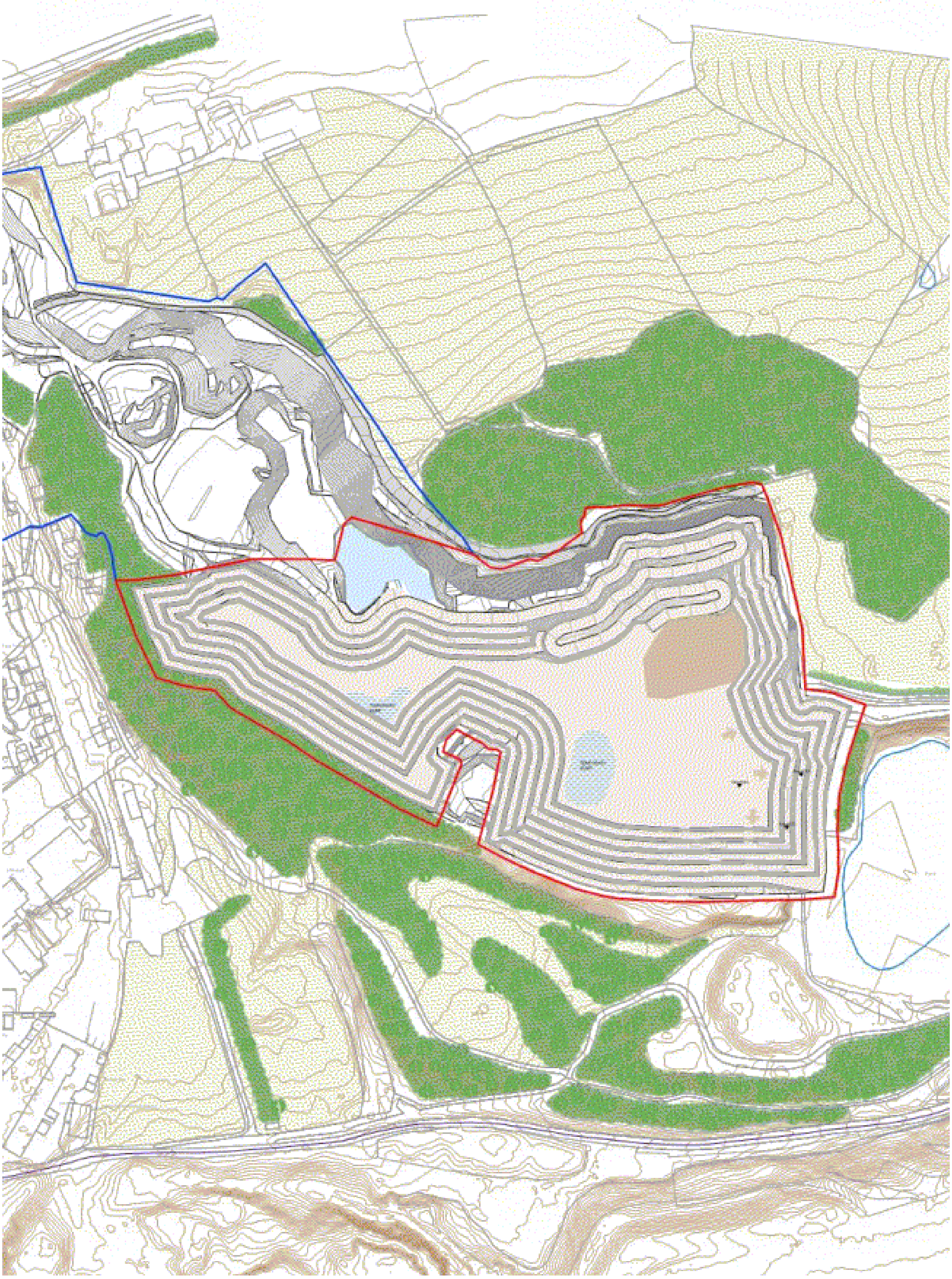


Figure 3-5 : Concept Restoration Scheme

4.0 ENVIRONMENTAL IMPACT ASSESSMENT

4.1 Background

The ES describes in detail the potential environmental effects of the ongoing development, with reference to:

- Landscape and visual impact (Chapter 5.0)
- Ecology (Chapter 6.0)
- Hydrology and Hydrogeology (Chapter 7.0)
- Noise (Chapter 8.0)
- Blast Vibration (Chapter 9.0)
- Air Quality (Chapter 10.0)
- Transportation (Chapter 11.0)
- Cultural Heritage (Chapter 12.0)

An overall summary of the environmental effects is set out in Chapter 13.0 which draws upon the main environmental issues set out in preceding chapters, and the recommendations for mitigation measures. This provides a link between the conclusions and recommendation of the topic studies, and the overall conclusions of the ES.

Further context is provided by the consideration of planning policy against which the application will be determined (Chapter 14.0), which highlights, inter alia, environmental issues which need to be addressed to satisfy planning policy requirements and advice.

Each technical chapter sets out the methodology adopted in the assessment, to include, where appropriate:

4.1.1 Approach to the Assessment:

- Desk based data collection, site survey, etc
- Guidance to be adopted [*GLVIA, BS4142 etc*];
- Sources of information [what, where obtained etc];
- Scoping and a cross reference to the Scoping Direction
- Relevant Planning Policy or Strategy referred to {must be relevant to topic and must be objective};
- How "*significance*" is defined ;
- Reference should be made to describing the 'characteristics' of the impacts (see further below).
- Reference should be made to defining the 'sensitivity' of receptors (see further below).
- Reference should be made to describing the 'nature' of the effects (e.g. direct/indirect, temporary (reversible)/permanent(irreversible) (see further below). A definition will be provided in the ES Glossary and thus the definitions of these terms do not to be re-explained in the text repetitively between chapters.

- How timescales (short, medium, long term) are defined in the assessment;
- Any interaction with other topics [in this case the particular importance of the inter relationship between hydrogeology and potential indirect ecological effects]; and
- Any technical difficulties.

4.2 Assessment Structure

The Welsh Government Scoping Opinion requests commonality within the technical assessments and in general, each Chapter includes sections which deal with:

- Baseline conditions;
- Key Receptors;
- Summary of development
- Design Mitigation
- Assessment
- Mitigation measures
- Residual impacts
- Cumulative effects
- Summary of effects
- Recommendations
- Planning Conditions
- Conclusions

In addition the ES includes a central glossary which sets oout technical terms that are used within each technical chapter.

5.0 LANDSCAPE & VISUAL IMPACT

5.1 Introduction

This Chapter provides an assessment of the potential for the landscape and visual amenity of the locality to be impacted by the development and has been prepared by Pleydell Smithyman Limited (PSL), Landscape Architects, Environmental Design and Business Consultants. PSL is a practice registered with the Landscape Institute and is a corporate member of the Institute of Environmental Management and Assessment.

This chapter provides details of the landscape and visual impact assessment undertaken in relation to the existing and proposed future quarry development at Gaens Quarry, Bridgend. The purpose of the study is to evaluate the landscape and visual impacts associated with the proposed development, determine the likely effects to the landscape and visual character of the area, and make recommendations for mitigation measures which can be used as the basis for planning conditions as part of the ROMP Review.

The Landscape and Visual Impact Assessment (LVIA) is a tool used to identify and assess the likely significance of the effects of change resulting from development both on the landscape as an environmental resource in its own right and on people's views and visual amenity.

The chapter (i) describes the existing environment; (ii) identifies and assesses the likely impact of the development on the receiving landscape, its elements, features and character; (iii) determines the visual extent of the proposed development; and (iv) assesses the effects of the development on identified key visual receptors within the developments zone of visual impact.

This chapter makes use of the following publications or web based resources:

- *Letter dated 20th June 2010 from Countryside Council for Wales.*
- *Scoping Direction dated 4th March 2013 from the Welsh Government, Department for Environment and Sustainable Development.*
- The *Landscape Character Map for Wales* (Land Use Consultants and Sheffield University for CCW, 2007).
- *Digital Historic Data based on Cadw Historic Assets Data. © Crown copyright. Cadw Licence No. 21082009.*
- *The Welsh landscape information resource LANDMAP* (http://test.landmap.ccw.gov.uk/) that is the responsibility of Natural Resources Wales.
- *The Welsh Government Inspire website* (http://inspire.wales.gov.uk/mapviewer/).
- *Minerals Planning Policy Wales, (*National Assembly for Wales, 2000).
- *Minerals Technical Advice Note Wales 1: Aggregates* (National Assembly for Wales 2004).
- *Bridgend Local Development Plan 2006-2021 -* Adopted September 2013.
- *Bridgend County Borough Council Designation of Special Landscape AreasMarch 2010.*
- *Vale of Glamorgan Council Special Landscape Areas - Integration With Adjoining Authorities.A Report Of The Review Exercise.*(TACP)April 2008

The Chapter should be read in conjunction with the various accompanying plans and photographs provided within Appendix 5/1.

5.2 Methodology

5.2.1 Assessment Approach

The methodology detailed below is in accordance with:

- *Guidance for Landscape and Visual Assessment- 3rd Edition, produced by the Landscape Institute and Institute of Environmental Management and Assessment 2013.*

The assessment process is intended to provide an objective method of establishing the significance of effect of a proposed development on an areas landscape character and visual amenity.

The landscape and visual assessment process consists of a number of stages as set out below:

- *Identification of the source/aspects of the development likely to give rise to effects.*
- *Identification of components/receptors most likely to be affected by the development.*
- *Description of the interaction of the receptors with aspects of the development.*
- *Assessment of the Nature of the Landscape and Visual Receptors (Sensitivity) in relation to the identified aspects of the development.*
- *Assessment of the Nature or Magnitude of Effects.*
- *Assessment of Mitigation Measures to be adopted.*
- *Assessment of the Significance of Residual Effects.*

A full description of the landscape and visual assessment methodology can be found within Appendix 5/2.

5.2.2 Scope of the Assessment

For reasons explained in Chapter 1.0, this ES is primarily concerned with the operational life of the quarry in totality rather than based on planning boundaries that no longer reflect the current or future physical extent of quarrying operations.

In brief, the Gaens ROMP area relates to the central and eastern area of Gaens Quarry to the north and west of Pant Mawr Quarry and Heol y Splot road. The ROMP area includes the plant site and main extraction void. The 1948 IDO area comprises the eastern half of the quarry including the weighbridge, offices and access road, as well as unrestored former quarrying working areas.

The Landscape and Visual Assessment therefore covers the totality of the Gaens Quarry development, and considers the effects of the full quarry development scheme, including extraction, processing, access, quarry waste disposal etc. This Chapter also includes an assessment of the potential for cumulative landscape and visual effects associated with quarrying activities associated with both the Cornelly and Grove Quarries that abut the site.

5.2.3 Landscape and Visual Elements of the Development

Gaens Quarry is active with mineral extraction currently taking place within a relatively small void to the east of the ROMP area. Access to the site is via a short link road onto the Porthcawl Road which joins to the roundabout on the A4229 to the north of South Cornelly, HGV's not being allowed to turn left into South Cornelly. the main quarry tip occupies a large visually prominent ridge which partly forms the southwestern boundary of the main void. The offices, weighbridge and fitting shop etc. are located some 100m away from the entrance, with an intervening agricultural field and behind a substantial hedgerow/tree belt. The processing facilities occupy a wide bench located at depth within the current quarry void and as such is not visible beyond the confines of the site. Former faces are also visible located within the northwestern half of the quarry. The main extractive and processing operations, apart from the quarry tip, therefore do not overtly intrude on, or adversely affect the surrounding landscape or visual amenity.

Currently, the former quarry faces within the northwestern half of the quarry that rise northwards into higher undulating ground associated with Old Ballas woods are generally hidden from most areas and are generally weathered blending in with the surroundings, but do become visible from Heol y Broom road between South Cornelly and Pyle and Kenfig Golf Club.

In terms of future development the proposals include both deepening the existing quarry void as well as lateral extensions to the northwest, within the ROMP.

Future proposals include extending the quarry laterally to the north, south and west, generally within the currently disturbed area, although the western extension includes a section of the currently wooded ridgeline that forms the southwestern boundary of the site. The development extends the quarry laterally to the permitted limit of extraction to a final face configuration that maximises the width of the quarry in order to allow deepening.

This operation will also involve the removal of the majority of the large overburden/quarry waste tip on the southwestern boundary in the short to medium term (5-10 years). The main quarry floor to the east is currently at some 9m AOD, with deepening planned to reduce this to some -20m AOD. This will take place over the next 10-15 years. The plant site is currently located to the west of the quarry void on a wide bench at some 37m AOD and following completion of this first phase of operations, the quarry will then be extended to the northwest into the area currently occupied by the processing plant and water management lagoon. At this time(+15 years), it is expected that the processing facilities will be relocated within the main quarry void. Overburden and quarry waste from these operations will be used to partially infill the main worked out western void.

Operational Stage.

These effects are primarily associated with direct physical changes to the fabric of the landscape associated with the continuing extraction of mineral and partial infilling with quarry waste materials during the remaining ~60 year operational life of the quarry. Indirect effects are also associated with temporary changes to the overall character of the landscape due to the presence of the quarry during its operational life. These physical and perceptual changes relate to the ongoing extraction and partial infilling with quarry waste until the area is retored to the proposed afteruses.

This is therefore a dynamic effect with levels increasing and decreasing as the phased mineral extraction, infilling and subsequent restoration progresses, potentially affecting different receptors at different time periods.

Restoration Stage.

These effects are those experienced by landscape and visual receptors following site restoration works to a combination of, naturally regenerating faces and scree slopes, calcareous grassland, woodland and other conservation afteruses with the main quarry void being allowed to fill with water once quarrying is complete to create an area of open water with wetland margins.

This again can be seen as a dynamic effect throughout the operational life of the quarry and beyond. In the medium to long term (20-25 years), upper faces/benches within the completed northeastern and southern halves of the quarry will be either progressively restored by treeplanting, or allowed to regenerate naturally thereby reducing the overall footprint of the quarry and allow these areas to begin to reach some form of maturity while the remainder of the site is still operational. In the longer term (+15 years),the progressive extension of the western faces will be treated in a similar way until all mineral extraction and infilling is complete, where upon grassland and additional trees/woodland planting will be established around the peripheral areas and the void allowed to gradually fill up with water. Once the site is fully restored (when water levels have reached their equilibrium level) the remainder of the quarry will be relatively mature.

5.2.4 Sources of Potential Visual Effects

Based on these two aspects of the development, sources of potential landscape and visual effects will differ during both the operational and post restoration stages.

Operational Stage.

During this stage sources of potential landscape and visual effects are associated with continued extraction of minerals and subsequent partial infilling with quarry waste generated during the extraction and processing stages including:

- The removal of relatively small areas of naturally regenerated vegetation/woodland within or around the periphery of the site associated with the outer faces of the large tip and old either completed or partially worked quarry faces and benches that will eventually be removed or overtipped.
- The creation of new faces and unrestored old faces;
- The broadening and deepening of the quarry void;
- Progressive infilling of the eastern quarry void to final restoration contours;
- Vehicle movements both internal and external to the site associated with extraction and infilling;
- Timescales associated with the operational life of the development.

Restoration Stage.

During this stage sources of potential landscape and visual effects are associated with the progressive and post restoration aspects, including:

- Surface treatment to complete restoration works;
- Subsequent grass seeding and tree planting works;
- Establishment and ongoing management during the operational life;

- Timescales associated with the landscape gradually becoming mature.

5.2.5 Nature of Effects

As well as identifying components of the development likely to affect landscape character and visual amenity of the locality, an assessment is also made as to likely interactions between the landscape and visual receptors identified and these components.

The level of interaction identified enables an assessment to be made as to the nature, or magnitude of effects associated with those aspects of the development as identified above.

This interaction is assessed by considering the *Size/Scale*, (expressed in terms of **Neutral** or **Very Small** or **Small** or **Medium** or **Large**or **Very Large**),*Geographical Extent* (expressed in terms of **Neutral** or **Very Small or Small or Medium or Large or Very Large**), *Duration* (expressed as either **Short** or **Medium** or **Long** or **Permanent**) and *Reversibility* (expressed as either **Fully** or **Partially** or **Permanent**) of those aspects of the development identified as likely give rise to either landscape or visual effects. This information is then combined to arrive at an evaluation of the overall nature or magnitude of effects on individual receptors.

5.2.6 Type of Effect

The type of effect the development generates is dependent upon both the nature of the development (see below), as well as the nature or sensitivity of the landscape or visual receptors that potentially receive some level of effect. The sensitivity of a receptor is dependent upon both their respective *susceptibility* to change with respect to the development, as well as any intrinsic or perceived *value*.

In landscape terms, susceptibility to change can be defined as being the ability of the landscape receptor (whether it be the overall character or quality/condition of a particular landscape type or area, or an individual element and/or feature, or a particular aesthetic and perceptual aspect) to accommodate the proposed development without undue consequences for the maintenance of the baseline situation.

The value of a landscape can be partly defined as being related to the level of designation, i.e. whether international (World Heritage Site), national (National Parks or Areas of Outstanding Natural Beauty) or local (Special Landscape Areas), or the presence of other designations linked to historic, natural or cultural elements (Scheduled Ancient Monuments, Historic Parks and Gardens, Ancient Semi Natural Woodlands, Conservation Areas, Listed Buildings etc.). However, all landscapes have a value which can also be determined by assessing its condition, scenic quality, rarity, representativeness, conservation interests, recreational value, perceptual aspects and other associations such as writers, artists etc.

There is a complex relationship between perceived value and susceptibility to change. Therefore a perceived high value landscape does not automatically have a high susceptibility to change.

In visual terms, susceptibility to change can be defined as being the type and relative number of receptors (people), the physical activity they are involved in, in combination with viewing direction, distance and elevation, as well as the nature of the viewing experience, such as static or transient and whether the view is panoramic in nature, a vista or just glimpses.

The value attached to views experienced by visual receptors takes account of recognition of the value attached to particular views, for example in relation to heritage assets, through planning or other designations, as well as by indicators of the value attached to views by visitors. This could include for example through appearances in guidebooks or on tourist maps, or through the provision of facilities for their enjoyment (such as parking places, sign boards and interpretive material) and references to them in literature or art.

An assessment was made of both *Susceptibility* and *Value* based on a five point textual scale: **Very Low**, **Low**, **Medium**, **High** and **Very High**. This information was then combined to arrive at an overall sensitivity value for the receptor as a whole which is also expressed as a five point textual scale ranging from **Very Low** to **Very High**.

The assessed nature and types of effects were considered according to whether they were *adverse*, *neutral* or *beneficial*.

5.2.7 Direct and Indirect Effects

Direct and indirect effects on the landscape and visual amenity of an area potentially affected by the development can be defined as comprising:

- Direct physical changes to the actual fabric of the landscape, including loss or changes to individual elements such as agricultural fields, trees, hedges, ditches, paths etc.
- Direct or indirect effects caused by the development to the overall character of the landscape and changes to the key characteristics that help define and create the distinctiveness of the local landscape, including aesthetic and/or perceptual aspects.

5.2.8 Scale and Level of Impact

The future development of both quarrying activities and progressive infilling with quarry waste material occurs generally within the limits of the existing quarry void (ROMP Review area), or previous quarry workings (IDO area).The main exceptions to this being associated with the western extension into part of the currently wooded ridgeline and the eastern extension into the ridgeline that separates Gaens from Pant Mawr Quarry.

The northeastern/southwestern boundaries (part of the Newton Down scarp slope) generally consists of mature woodland or agricultural fields, the eastern and southeastern boundaries by naturally regenerated scrub/woodland associated with previous workings/tipping operations within the former Pant Mawr Quarry area and the northwestern boundary by agricultural fields bounded by a thick treebelt adjacent to the site.

The existing quarry occupies a somewhat elevated position at the edge of an expansive plateau with levels ranging from some 37m AOD to the west and some 84m AOD to the east. Due to this increase in levels eastwards, heightened by the presence of the valley feature to the south associated with Pant Mawr Quarry and Heol y Splot road, the southern tip rises dramatically from the adjacent valley forming an isolated hill, exaggerated by the presence of quarry voids both to the north and east. This tip therefore become generally open to view from receptors to the west and southwest of the site above the level of the intervening woodland.

Therefore, the scale and level of potentially adverse effects on the localities landscape character and visual amenity associated with the existing quarry workings is associated with the prominence of the tip or old faces within the western IDO area and restricted to receptors to the west and southwest. The former faces are generally only visible within 1.5km of the site, whereas the tip is associated with longer distance effects, albeit within a relatively narrow band associated with South Cornelly, the southern section of the Pyle and Kenfig Golf Club, including the southern section of the Kenfig Pool and Dunes area and westwards towards Sker Point.

The primary landscape effects associated with future workings will be in regard to the removal of the majority of this large tip and the western lateral extension into the wooded ridgeline. The removal of the tip, while resulting in the removal of a prominent discordant feature within the local landscape, may result in opening up the high active northeastern backfaces to view from the southwest. This may also be the case in terms of the lateral extension. However, wooded outer lower slopes of both the tip and the lateral extansion are expected to remain which may partially mitigate adverse effects associated with these aspects of the development.

5.2.9 Mitigation Measures

As described above the extraction of remaining Gaens Quarry includes a somewhat elevated position on the western edge of an expansive plateau and is generally bounded by either woodland, hedgerows/treebelts, scrub vegetation, or agricultural fields, which limits effects to a narrow corridor to the west/southwest of the site. Within proximity to the site, the main landscape and visual effects are associated with the old disused faces and the upper active sections of the quarry tip.

Future proposals include the removal of this tip as a 'built-in' mitigation measure in the short to medium term (5-10 years). These proposals also include for the partial infilling of the western half of the old void with quarry waste which, in both the medium and longer term, will also mitigate adverse effects associated with this aspect of the site.

It is therefore proposed that a screening bund is constructed along the southwestern site perimeter (IDO area) and subsequently planted with trees to allow tipping of quarry wastes to proceed behind this structure until the final restoration of this area.

A full description of the proposed mitigation measures for the site is included in Section 5.6 below.

5.3 Policy Context

5.3.1 Relevant Planning Policy

This section identifies the relevant national guidance and local development plan policies, which provide a context against which this ROMP Review will be considered. Specifically these comprise relevant sections of the *Minerals Planning Policy Wales (2000)*, the accompanying *Mineral Technical Advice Note Wales 1: Aggregates (2004)* and the *Bridgend Local Development Plan 2006-2021(2013)* policies.

Chapter 14.0 of the ES considers planning policy and the way in which it assists in identifying issues of relevance to the ROMP Review and formulation of updated planning conditions. This section does not seek to duplicate that analysis or provide lengthy quotations of policy and text, but rather it summarises and lists the key policies which are most relevant in determining the impact on landscape and visual receptors.

Minerals Planning Policy Wales (MPPW)

MPPW sets out a number of core objectives, which include the need to protect areas of importance to the natural and built heritage from inappropriate mineral development (including Special Landscape Areas (SLA) and Historic landscapes parks and gardens). The quarry does not lie within an SLA, although land to the west of Stormy Down Quarry forms part of an extensive SLA running to the western outskirts of the built up area of Bridgend (ref SLA7 Laleston – Figure 6.2 of Appendix 5/1).

MPPW also seeks to reduce the impact of mineral extraction and related operations during the period of working by, for example, ensuring sensitive working practices and improved operating standards. The development scheme seeks to respect this requirement.

MPPW also highlights the importance of achieving a high standard of restoration and aftercare, and provide for beneficial after-uses when mineral working has ceased. As noted above, provision for the restoration of Gaens Quarry has been made as part of this submission (ref ES Chapter 4.0).

Mineral Technical Advice Note Wales 1: Aggregates (MTAN1)

Similar requirements are set out in MTAN1, with specific objectives to prevent unacceptable aggregates extraction from areasof acknowledged landscape, cultural, andgeological conservation and importance; to minimise impact on the historic environment; to minimise visual impact, and to achieve a high standard of restoration and aftercareand provide for a beneficial after-use

Bridgend Local Development Plan 2006-2021

Of significance to the LVIA is the requirement to protect, conserve and enhance the natural environment (Policy SP4), while protecting the County's natural mineral resource (Policy SP6). This also includes safeguarding the Countryside from development (Policy ENV1), having particular regard to Special Landscape Areas (Policy ENV3),Landscape Conservation Areas (Policy EV10(2), Nature Conservation Areas (Policy ENV6), as well as the historic and built environment (Policies SP5 and ENV 8).

5.4 Landscape Assessment

5.4.1 Landscape Baseline

Within this section the baseline conditions or the description of the environmental conditions against which any future changes can be measured or predicted are assessed with regards to Landscape Character and Visual Amenity.

Landscape Character is defined as '*a distinct, recognisable and consistent pattern of elements in the landscape that made one landscape different from another, rather than better or worse'* (GLVIA Third Edition 2013).

A Study area has been defined based on the extent of the existing Zone of Theoretical Visibility (ZTV). This plan (Figure 6.5 of Appendix 5/1) identifies both the Cornelly ROMP boundary (blue line) and the Cornelly and Grove IDO boundary (red line). The ZTV has however been generated using the limit of currently disturbed land, based solely on landform. This precludes the screening effect of surrounding vegetation and built development.

Landscape Setting

The total area of Gaens Quarry equates to some 23ha. of which some 12.72 ha. falls within the ROMP Review boundary. The majority of this area is, or has been previously disturbed. A small area in the western corner of the ROMP boundary appears to be undisturbed, associated with the edge of the scarp slope that falls away to the valley feature associated with Heol y Splot road. This equates to some 0.9ha.

The quarry itself is located on the edge of a broad upland plateau area, with levels ranging between 40m and 80m AOD. The eastern boundary of the site abuts the former Pant Mawr Quarry void, which forms part of the wider Cornelly and Grove Quarry complex, after which the Newton Down plateau gently rises in a series of small undulations to the northeast to 108m aOD at Stormy Down. Further eastwards the landform remains at a similar level before falling gently away towards Lalestron /Trelales due east and Tythegston to the southeast as a series of small valley features. These valleys are occupied by both local and national road networks (A48 linking Bridgend with Pyle).

The southern boundary of the site falls away into the valley feature associated with Heol y Spolt road after which the landform rises again to form part of either the existing or proposed future workings associated with Grove Quarry. Beyond this the edge of a scarp slope reaches between some 50-75m aOD before falling away towards the A4229 and the Porthcawl coastal plain.

The northern boundary of the site consists of woodland or treebelts that either form a small isolated hillock which falls away more steeply as a localised scarp slope in proximity to Old Ballas Wood, which reaches an elevation of some 85m AOD. Further afield to the northeast, beyond Stormy Down, the land falls away more rapidly towards the Afon Fach valley, a tributary of the main incised valley of Afon Cynffig further to the west which drains into the Bristol Channel between Margam Moors and Kenfig Dunes. The M4 motorway corridor cuts through the edge of this escarpment, bisecting Stormy Down in two. The town of Pyle extensively occupies the valley where these two rivers meet, as well as the lower lying hillocks that surround these valleys.

To the west, the slope continues to fall away towards the lower lying land thatforms the coastal plain at some 20m AOD. This slopeis bisected by a small narrow valley that links into the main incised valley of AfonCynffig further to the north, or small valleys that drain away towards the sea to the south of Sker Point. The valley feature itself is occupied by a small minor road (Heol-y-Splot) which now forms the main access into both Cornelly and Grove quarries. Originally this road linked with Mount Pleasant Road to the east of the site, but is now cut off as the northern half of Cornelly Quarry has worked through the line of the road (ref: formal Road Closure Order 2007).

The eastern boundary of the main quarry void is defined either by agricultural fields that form part of the hillock associated with Old Ballas Woods at some 80-85m AOD.

The landform immediately to the southwest of Gaens Quarry falls away steeply as a wooded escarpment, the toe of which is defined by the carriageway of the Heol-y-Splot and the eastern outskirts of South Cornelly defined by a small cul-de-sac identified as Lamb Row on OS mapping. The ROMP extraction boundary extends into this wooded ridgeline down towards this road (Lamb Row), being some 25m from the nearest property located along this road (Rock Cottages). The nearest previously worked face is currently some 50m away from this property.

As a consequence of the location of the quarry on the western edgeof this upland plateau area, in conjunction with the surrounding topographical features, the quarry is generally well screened from view and enclosed by the existing landform and vegetation within the general landscape setting from receptors to the north, east and south. However, as described earlier, the location of the valley feature associated with Heol-y-Splot road abutting the site to the southin conjunction with the size and location of the southern tip allows this feature as well as previously worked back faces of the western quarry area to become generally open to view, albeit restricted to a relatively narrow angle from the northwest to the southwest.

Designations

Figure 6.2 of Appendix 5/1 illustrates the main landscape and nature conservation designations within a 20km^2 Study Area. The Site is NOT located within any nationally designated landscape (i.e. a National Park (NP) or an Area of Outstanding Natural Beauty (AONB)). There are no UNESCO World Heritage Sites (WHS), Ramsar, or Special Protected Areas (SPA) within 10km of the site boundary. However, a number of Special Landscape Areas, Historic Landscape Areas, Special Areas of Conservation (SAC),Scheduled Ancient Monuments, Site's of Special Scientific Interest, National and Local Nature Reserves, Site of Important Nature Conservation, Historic Parks and Gardens, Listed Buildings, areas of Ancient Woodland and Long Distance Recreational Routes are present within the Study Area (see below).

*Special Landscape Areas:*There are a total of four Special Landscape Areas within 3.0km of the Site. These include SLA6 Kenfig Burrows;SLA7Laleston; SLA8 Porthcawl Coast; and SLA9 Merthyr Mawr Warren. The closest to the site is SLA6 Kenfig Burrows which lies some 1.9km to the west.

*Historic Landscape Areas:*There is a single Historic Landscape Area within 3.0km of the Site. Thisis the Merthyr Mawr, Kenfig & Margam Burrows HLA, although consists of two physically separate areas lying some 1.7km to the west and 3.2km to the southeast of the site.

Special Areas of Conservation (SAC): There are two SAC's within 3.0km of the Site. These include Kenfig Dunes and Burrows and Cefn Cribwr Grasslands. Although only two designations they occupy six physically distinct areas of which three are located within 3.0km of the site.

Scheduled Ancient Monuments (SAM): There are a total of nine Scheduled Ancient Monuments within 3.0km of the Site, none of which are located within 1.0km. The largest SAM within the study area is associatedwith Merthyr Mawr Warren which lies approximately 4.0km to the southeast of the site and the closestis thePyle Incised Stonewhich lies approximately 1.8km to the north of the site.

Sites of Special Scientific Interest (SSSI): There are a total of nine SSSI's located within 3.0km of the site. The nearest is associated with the Kenfig Dunes SSSI, some 2.1km to the northwest of the site.

*National Nature Reserves (NNR):*There are two National Nature Reserves within 3.0km of the Site. These consist of the Kenfig Sands and Dunes NNR to the northwest and Merthyr Mawr Warren NNR to the southeast.

*Site of Important Nature Conservation (SINC):*Several SINC's are located within the Study Area. The nearest is associated with Frog Pond Wood to the east of Pyle some1.8km to the northeast of the Site.

*Local Nature Reserves (LNR):*There arethreeLocal Nature Reserves within 3.0km of the Site. These consist of the Kenfig Sands and Dunes LNR to the northwest, Lock's Common LNR to the south and Frog Pond Wood LNR to the northeast.The nearest is associated with Frog Pond Wood to the east of Pyle some 1.8km to the northeast of the Site.

*Historic Parks and Gardens:*There is a total of three Historic Parks and Gardens located within the Study Area. The nearest is associated withTythegston Court some 3.2km to the southeast.

CADW Listed Buildings and Monuments: There are a number of CADW listed buildings and historic environment records within 3.0km of the Site. The nearest listed buildings lie within the village of South Cornelly associated with Ty-maenhouse and walled gardens, some 275m to the southwest of the site.

Ancient Woodland: Some seven tracts of ancient and semi-natural woodland are scattered within 3.0km of the Site. The nearestblock associated with Old Ballas wood forms the northern boundary of the ROMP area.

Long Distance Recreational Routes: Two Long Distance Recreational Routes are located within the Study Area. The Wales Coast Path is located some 3.5/1.9/2.0km to the south, west and north of the site respectively. The Bridgend Circular Walk is located some 3.7km to the east of the Site.

Landscape Character

The assessment of an area's landscape character and its ability to accommodate change is initially based on the categorisation of landscape features and elements that combine to create the distinctive character of an area. Landscape character comprises a description and assessment of the distinct and recognisable pattern of elements and features that occur consistently in a particular type of landscape and how this is perceived.

In 2007 the Countryside Council for Wales (CCW - now Natural Resources Wales (NRW)) at a national level produced a Landscape Character Map for Wales, similar to those previously produced for England and Scotland by Natural England and Scottish Natural Heritage. This document has now been largely superseded by LANDMAP, the Welsh approach to landscape assessment, which is a Geographical Information System (GIS) based landscape resource where landscape characteristics, qualities and influences on the landscape are recorded and evaluated into a nationally consistent data set. Some local authorities have utilised this database to produce a Landscape Character Map for their administrative area, although Bridgend CBC have not done so. Therefore, this assessment utilises the boundaries identified within the LANDMAP national information system, which consists of differing 'Aspects' covering the five physical and sensory senses which can be said to constitute the main characteristics of any landscape.

These are:

- Visual and Sensory
- Landscape Habitats
- Historic Landscape
- Cultural Landscape
- Geological

The overall characteristics of the landscape are therefore made up of a combination of physical, environmental, cultural and sensory factors. However, it is the visual nature of the development that is primarily being assessed so this study therefore utilises the Visual and Sensory Aspect (V&S) as the principle Aspect to be evaluated which also constitutes the main visual and landscape characteristics of the areas potentially affected by the development. Figure 6.3 of Appendix 5/1 LANDMAP Visual and Sensory Aspects Plan shows the location of these Aspects in relation to the location of the development within the Study Area.

Reference is also made within the assessment section to the overall generic sensitivities as set out within LANDMAP that covers all Aspects within the Study Area. See Figure 6.4 of Appendix 5/1 LANDMAP Overall Generic Sensitivity Plan.

5.4.2 Identification of Potential Landscape Receptors

At a national level the site is located within Swansea Bay Character Area (LCA38) as identified by the Landscape Character Map for Wales and is therefore capable of experiencing direct effects from the development.

The LANDMAP database identifies approximately twenty four Visual and Sensory Aspects (V&S) occurring within the Study Area. The site has been identified as being located within the Newton Down V&S Aspect and is therefore capable of experiencing direct effects from the development. In addition, a further six V&S Aspects within the Study Area have also been identified as being capable of experiencing indirect effects from the development. These include Pyle V&S; Porthcawl Hinterland V&S; Porthcawl V&S; Kenfig Burrows V&S; Kenfig Sands V&S; and Newton Point V&S. Descriptions of these Aspects have been included within Appendix 5/3.

The following description of the Newton Down Visual and Sensory Aspect potentially directly affected by the proposed development as listed below has been taken from the LANDMAP database.

Visual and Sensory: Newton Down

The Aspect Area Classification as described within the LANDMAP database states that this Aspect consists of:

Lowland/Rolling Lowland/Open Rolling Lowland

The Summary Description of this area as described within the LANDMAP databases states that:

> *This area is largely comprised of a raised plateau at approximately 100m AOD, the area also includes the slope that runs downwards to the level lowlands of the Porthcawl hinterland to the south. The area is predominantly farmland with both arable and pastoral elements being present within field enclosures bordered by hedgerows. On top of the plateau there is an open exposed feel. There are views out to Porthcawl and the coast from the southern slopes. Within the landscape their are a number of incongruous elements such as a stone quarry, civic amenity site and old airfield/semi-derelict industrial site, these are quite well screened from the surrounding landscape however. The M4 and A48 both pass through the Aspect Area and have both a visual and noise influence.*

The LANDMAP database gives an Evaluation of various perceptual characteristics of the Visual and Sensory Aspect including:

Scenic quality:	Moderate (Some attractive views out to coast.)
Integrity:	Moderate (Generally unspoilt, with some notable exceptions/detractors e.g. stone quarry and disused airfield.)
Character:	Moderate (Area has a moderate sense of place.)
Rarity:	Moderate (Not a particularly rare landscape.)
Overall Evaluation:	Moderate (All criteria moderate.)

The LANDMAP database gives Justification of Overall Evaluation which states:

All criteria are moderate with no obvious very valuable areas and no detractors significant enough to reduce value to low.

The LANDMAP database gives an evaluation of the Perceptual and Other Sensory Qualities of this Aspect which states:

Exposed (On the top of the plateau can be quite exposed.)
Settled (The area did appear to be settled, certainly this is the case away from the two main road corridors that influence this area (M4, A48).)

The LANDMAP database gives an evaluation of the Sense of Place/Local Distinctiveness of this Aspect which states:

Moderate (The M4, and views to the coast give the area a certain sense of place but are far from being features unique to the Aspect Area.)

The LANDMAP database gives an evaluation of the condition and value/quality of each Aspect along with an overall trend as to its predicted future condition.

Value:	Moderate (The area is relatively unspoilt with some attractive views outwards.)
Condition:	Fair (No obvious signs of degradation.)
Trend:	Unassessed (Based on field work by PSL and the findings above the overall trend of this Aspect is constant.)

The following description of the Porthcawl Hinterland Visual and Sensory Aspect potentially indirectly affected by the proposed development as listed below has been taken from the LANDMAP database.

Visual and Sensory: Porthcawl Hinterland

The Aspect Area Classification as described within the LANDMAP database states that this Aspect consists of :

Lowland/Flat Lowland/Levels/Flat Open Lowland Farmland

The Summary Description of this area as described within the LANDMAP databases states that:

An area of relatively flat lowland that is largely comprised of pastoral agriculture fields surrounded by hedgerows. It is distinct from the raised plateau of higher ground to the north. The settlement of Porthcawl which this area borders is a dominant feature in views out of the area. Despite the nearness to the coast, the low lying of the land and Porthcawl obscuring much of the views to the south mean that this area has limited views out to the sea and resultantly does not have a coastal feel (the area between Lock's Common and Sker Rocks does have significant views out to the coast however). In the northwest corner the M4 can be a significant visual and noise feature. The presence of a number of caravan parks and golf course establishes the area for recreation and tourism.

The LANDMAP database gives an Evaluation of various perceptual characteristics of the Visual and Sensory Aspect including:

Scenic quality: *Moderate (Some attractive views out to coast and Kenfig Burrows, also detractive views to Porthcawl, M4 motorway and Port Talbot industrial areas in distance.)*

Integrity: *Moderate (Generally unspoilt, with some notable exceptions/detractors e.g. urban edge of Porthcawl and M4.)*

Character: *Moderate (The area has a moderate sense of place.)*

Rarity: *Moderate (Not a particularly rare landscape, views out to sand dunes are distinct.)*

Overall Evaluation: *Moderate (All the criteria are moderate.)*

The LANDMAP database gives Justification of Overall Evaluation which states:

The area is typical of rolling lowland agricultural dominated land, it is relatively unspoilt and has some attractive views out as well as some detractive views.

The LANDMAP database gives an evaluation of the Perceptual and Other Sensory Qualities of this Aspect which states:

Noisy (Near to M4 can be noisy otherwise the area is generally not noisy.) Settled (Area has a settled feel to it as there is no hustle and bustle or a great deal going on.)

The LANDMAP database gives an evaluation of the Sense of Place/Local Distinctiveness of this Aspect which states:

Moderate (There is no great sense of place in the centre of Aspect area but areas with views out to Dune systems or the coast give the area a distinctive sense of place.)

The LANDMAP database gives an evaluation of the condition and value/quality of each Aspect along with an overall trend as to its predicted future condition.

Value: *Moderate (The area exhibits the character of a lowland agricultural landscape with few distinct visual & sensory features. However the limited views out to the coast offer visually valuable elements.)*

Condition: *Fair (Nothing obvious.)*

Trend: *Unassessed (Based on field work by PSL and the findings above the overall trend of this Aspect is constant.)*

5.4.3 Sensitivity of Landscape Character

As described in Section 5.2.6 above, landscape sensitivity, or nature of the receptor, is ascertained by combining judgements about its *susceptibility to change* arising from the specific proposal with judgements about the *value* attached to the receptor. This sensitivity is also based on whether the landscape receptor receives either direct or indirect effects from the proposed development.

Judgements about the susceptibility of the landscape to change can, in part, be informed by generic sensitivities that have been identified as part of the LANDMAP data acquisition process. Figure 6.4 (of Appendix 5/1) LANDMAP Overall Generic Sensitivity Plan highlights the generic sensitivities contained within LANDMAP not only for each of the five Aspects within the Study Area, but also shows them combined together to portray an overall generic sensitivity.

As can be seen from this plan, the generic sensitivity of the Visual and Sensoryand Historic Landscape Aspects within which the Site falls is assessed as being 'Moderate';the Landscape Habitat is assessed as 'Low' and the Cultural and Geological Landscape Aspects have been identified as being of 'High' sensitivity. No Aspects have been assessed as being 'Outstanding'.

Newton Down Visual and Sensory Aspect

In relation to the *susceptibility* of Newton Down Visual and Sensory Aspect to change, LANDMAP states that generic sensitivity value of ''Moderate'' given for all of the criteria (scenic quality, integrity, character and rarity) The 'Moderate' value being given due to it being generally unspoilt with some attractive views out to the coast, with some notable exceptions/detractors such as the stone quarries and disused airfield, plus not being a particularly rare landscape with no strong sense of place.

Based on the above, in combination with the location of the site on the edge of an upland plateau, the rolling nature of the local landform,the generally expansive nature of the landscape, plus the location of woodland blocks within the vicinity of the quarry, limits the extent of potential adverse effects. Potential susceptibility is also reduced by the presence of other detractors within this Aspect such as other quarries within the immediate vicinity, plus the M4 Motorway corridor to the north. These factors, along withthe location and type of landscape receptors, the susceptibility of this landscape to change is therefore considered to be **Low**.

In relation to the *value* of Newton Down Visual and Sensory Aspect, LANDMAP states that this Aspect is 'Moderate' being in Fair *condition* with with PSL's evaluation of future trends being Constant. Designations include the northeastern half of the Aspect being designated as a Special Landscape Area (Laleston), which incorporates Stormy Down. Four Scheduled Ancient Monuments are also present, two SSSI's, as well as Tythegston Court Historic Park and Garden, with the manor also being a listed building, plus other listed buildings/monuments within thevicinity. The perceived value of this landscape is therefore considered to be **High**.

Landscape sensitivity, or nature of the Newton Down Visual and Sensory Aspect receptor, arising from the development based on both *susceptibility to change* and perceived *value* results in a combined **Medium** Sensitivity to change. (ref Appendix 5/2 Table 6 and as reproduced below).

Table 5-1:Landscape and Visual Receptors: Overall Nature of Receptor (Sensitivity)

		Value of the Landscape/Visual Receptor				
		Very High	High	Medium	Low	Very Low
the Land scap	Very High	Very High	Very High	High	Medium	Medium

	High	Very High	High	High	Medium	Medium
	Medium	High	High	Medium	Medium	Low
	Low	High	Medium	Medium	Low	Low
	Very Low	Medium	Medium	Low	Low	Very Low

The other Aspect that has been assessed as potentially receiving higher levels of indirect landscape effects from the development include:

- *Porthcawl Hinterland; and*
- *Special Landscape Areas*

Porthcawl Hinterland Visual and Sensory Aspect

In relation to the *susceptibility* of the Porthcawl Hinterland Visual and Sensory Aspect to change, LANDMAP states that generic sensitivity value of ''Moderate'' given for all of the criteria (scenic quality, integrity, character and rarity) The 'Moderate' value being given due to it being typically rolling lowland agriculturally dominated land that is relatively unspoilt with some attractive views out but also has some detractive views.

Based on the above, in combination with the location of the site on the edge ofthe upland plateau area to the east, the rolling nature of the local landform, the generally expansive nature of the landscape with seascape to the west, plus the location of woodland blocks within the vicinity of the quarry, limits the extent of potential adverse effects. Potential susceptibility is also reduced by the presence of other detractors within this Aspect such as other quarries within the immediate vicinity, plus the M4 Motorway corridor to the north. These factors, along with the location and type of landscape receptors, the susceptibility of this landscape to change is therefore considered to be **Low**.

In relation to the *value* of Porthcawl Hinterland Visual and Sensory Aspect, LANDMAP states that this Aspect is 'Moderate' being in Fair *condition* with with PSL's evaluation of future trends being Constant. Designations include the western boundary of the Aspect being partly within a Special Landscape Area (Porthcawl Coast), incorporating Lock's Common and part of Sker Point; as well as an Historic Landscape Area (Merthyr Mawr, Kenfig & Margam Burrows); a SSSI (Kenfig Burrows); plus a number of listed buildings are also present, including Sker House. The perceived value of this landscape is therefore considered to be **Moderate.**

Landscape sensitivity, or nature of the Newton DownVisual and Sensory Aspect receptor, arising from the development based on both *susceptibility to change* and perceived *value* results in a combined **Medium** Sensitivity to change.

The other Aspects that has been assessed as potentially receiving some level of indirect landscape effects from the development include:

- *Pyle*
- *Porthcawl*
- *Kenfig Burrows*
- *Kenfig Sands*
- *Newton Point*

- *Coedhirwaun*
- *Cribwr*

Descriptions of the assessed overall sensitivity, or nature of these landscape receptors are included within Appendix 5/3.

Special Landscape Areas

TACP Consultants were appointed in October 2009 by Bridgend County Borough Council to carry out a review of Special Landscape Areas (SLAs) designation within their administrative area. The study reviewed the whole of the County Borough Council area. The previous Unitary Development Plan identified two forms of "special landscapes" within the Borough, identified as *The strategic coalfield plateau and its associated valley sides* and *Landscape Conservation Areas (*LCAs). As part of TACP's revised landscape assessment it was recognised that it was likely that these LCAs would have to be reviewed in the light of this assessment. The Special Landscape Area Study highlighted nine areas which qualify under the revised methodology as candidate SLAs. These were subsequently included as part of the *Bridgend Local Development Plan 2006-2021*, adopted in September 2013.

Two SLAs were assessed as potentially receiving some degree of effect from the existing or proposed development. These are:

- *Kenfig Burrows SLA*
- *Porthcawl Coast SLA*

Kenfig Burrows SLA

As stated within the TACP Report (*Bridgend County Borough Council Designation of Special* Landscape Areas March 2010), this SLA forms a distinctive landscape within the County Borough and is subject to a range of statutory designations, including a Special Area of Conservation, Site of Special Scientific Interest, National and Local Nature

Reserve and is included on the Register of Landscapes of Outstanding Historic Interest in Wales.

The SLA consists of a group of windblown littoral sand deposits found along the South Wales coast, Culturally it represents an important besanded landscape that derived from adverse weather conditions and tidal phenomena in the Middle Ages, which had considerable impact upon local societies. Kenfig forms an extensive dune system that overlies the Upper Carboniferous Limestone. It includes intertidal zone between Kenfig Nature Reserve looking north towards M4 Kenfig Nature Reserve looking east Kenfig Nature Reserve looking west across Kenfig Pool mean low and high water lines, and in places strips of storm gravels are found on the wave cut platform. Within the dune system are a number of ponds and water bodies, the most significant being Kenfig Pool which lies close to the visitor centre and car park. Its land form is a distinctive landscape unit, providing a unique foreground setting to the industrial and transport communication corridors (M4 motorway and Swansea-London railway line).

The susceptibility of the Kenfig Burrows SLA to change (as it relates to the Kenfig Burrows, Kenfig Sands, Newton Point and Porthcawl Hinterland V&S Aspects), the TACP report identifies that the Overall Evaluation of the Visual and Sensory within the LANDMAP database is identified as being High and Moderate; Landscape Habitats as ranging between Moderate and

Outstanding; the Geological Aspect as being Outstanding; the Historic Aspect as being High or Outstanding; and the Cultural Aspect as being High or Outstanding.

Based on the above, in combination with the undulating and generally expansive nature of the local landform, the distance from the Site, its location on the edge of an upland plateau, plus the presence of woodland blocks within the vicinity of the quarry limiting the extent of potential adverse effects, the susceptibility of this landscape to change is therefore considered to be **Medium**.

In relation to the value of Kenfig Burrows SLA this area is recognised within the LDP under Policy ENV3 Special Landscape Areas have been designated to protect areas that have an intrinsic landscape character and quality both within Bridgend Borough Council and in a sub-regional context. Other designations include a SAC, SSSI, NNR, LNR and a Landscape of Outstanding Historic Interest in Wales. The perceived value of this landscape is therefore considered to be **Very High**.

Landscape sensitivity, or nature of the Kenfig BurrowsSLA receptor, arising from the development based on both susceptibility to change and perceived value results in a combined **High** Sensitivity to change.

Porthcawl Coast SLA

As stated within the TACP Report (Bridgend County Borough Council Designation of Special Landscape Areas March 2010), this SLA consists of a distinctive landscape which forms the coastal setting of Porthcawl. The SLA extends from Sker Point to Newton Point, the area is formed primarily by the intertidal zone that fronts Porthcawl and its hinterland. It is a mixture of exposed rock (Sker Point which lies within the Kenfig SAC, Hutchwns Point, Irongate Point, Porthcawl Point and Newton Point) and sandy beaches including Rest Bay, Sandy Bay and Trecco Bay. The exposed rocky outcrops form an important area of limestone pavement. In the west it abuts the Royal Porthcawl Golf Club as well as the landscape setting of Sker House. At Porthcawl it includes Lock's Common (a Local Nature Reserve and RIGS), but excludes the remainder of the urban area. The close juxtaposition to the town increases the range of visual and sensory detractors, particularly at Trecco Bay. It forms an important and much appreciated seascape setting to the important visitor destination that Porthcawl remains.

The susceptibility of the Porthcawl CoastSLA to change (as it relates to the Kenfig Sands Newton Point and Porthcawl Hinterland V&S Aspects), the TACP report identifies that the Overall Evaluation of the Visual and Sensory and Landscape Habitats within the LANDMAP database is identified as ranging between Moderate and High; the Geological Aspect as being Outstanding; the Historic Aspect as being High or Outstanding; and the Cultural Aspect as being High.

Based on the above, in combination with the restricted width, the adjacent built environment, the generally expansive nature of the local landscape (seawards - away from the site), the distance and the location of the site within an upland plateau, plus the woodland blocks associated with the intervening scarp slope limiting the extent of potential adverse effects, the susceptibility of this landscape to change is therefore considered to be **Low**.

In relation to the value of Porthcawl Coast SLA this area is recognised within the LDP under *Policy ENV3 Special Landscape Areas* have been designated to protect areas that have an intrinsic landscape character and quality both within Bridgend Borough Council and in a sub-regional context. Other designations include the boundary overlapping parts of a SAC, SSSI, NNR, LNR and a Landscape of Outstanding Historic Interest in Wales. The perceived value of this landscape is therefore considered to be **High**.

Landscape sensitivity, or nature of the Porthcawl Coast SLA receptor, arising from the development based on both susceptibility to change and perceived value results in a combined Medium Sensitivity to change.

5.4.4 Magnitude of Landscape Change

The nature of landscape effects are to an extent interlinked to the visibility of the proposed development within the landscape. Consequently, distance from the site and the degree of visibility of the development will generate differing magnitudes of effects from different locations. The potential nature, or magnitude of effect has been assessed from both desktop studies undertaken during the generation of the Zones of Theoretical Visibility (ZTV). A total of four studies were undertaken (see Figures 6.5 to 6.8 (of Appendix 5/1)). These include:

- The current Situation (Gaens Quarry only)– Figure 6.5.
- The current Situation (Gaens, Cornelly and Grove Quarries combined)– Figure 6.7.
- The proposed full development (Gaens Quarry only)– Figure 6.6.
- The proposed full development (Gaens, Cornelly and Grove Quarries combined) – Figure 6.8.

The ZTV's produced illustrates both the potential visual envelope of the existing quarry, as well as that of the proposed future development area(s). This information is displayed overlain onto a 1:25,000 OS base that shows detail down to individual field boundaries and footpaths. An opacity of topographic shading has also been added to help illustrate how the ZTV relates to the surrounding landform.

The ZTV studies of the existing situation (Gaens Quarry only and Gaens, Cornelly and Grove Quarries combined) both show that the potential visual envelope is primarily orientated to the west and southwest towards the lower lying agricultural fields between South Cornelly, north Porthcawl (Nottage), Sker Rocks and Sker Court between 1.0 - 3.0km from the site. However, the presence of strong mature woodland blocks associated with the central valley feature and the northern/western/southwestern perimeters of the site, plus the location and orientation of the existing quarry faces restricts the magnitude of landscape and visual effects from certain locations within this area.

Potentially this visual envelope extends to the northwest to include the western outskirts of Pyle. However, minor variations in the landform around the perimeter of the site, as well as intervening vegetation generally prevents these from occurring in reality, apart from potentially very minor effects associated with the very top of the quarry tip which may be visible from certain locations, especially in the winter months. Field study has confirmed that landscape and visual effects of the Gaens development are generally associated with either the active quarry tip, which can be seen as forming a skyline feature within a limited band either due west or to the southwest of the quarry, or former faces within the northwestern section of the quarry, set against a wooded backdrop to the north and northeast of the quarry.

Landscape and visual receptors within this area are generally associated with the minor road network, Pyle and Kenfig Golf Club, an occasional isolated farmhouse/dwelling, or the local footpath or bridleway network. Due to orientation, local variations in landform (in particular the dunescape) and vegetation patterns generally limit effects to between 1.0-3.0 km. of the site.

The two ZTV's of the future extraction area (Gaens Quarry only andGaens, Cornelly and Grove Quarries combined – Figures 6.6 and 6.8 (of Appendix 5/1)) both show that the potential visual envelope is very similar in extent to the existing situation. This is due to the proposed development associated with both lateral extensions and deepening being generally confined to the area that is already currently disturbed, or not breaking through the visual ridgeline, as well as also being partly obscured by the retained wooded lower slopes of the scarp slope in conjunction with the wooded outer slopes that forms the western southwestern boundary of the site.

It should be noted that the ZTV was generated from a digital terrain model of the landform only; therefore it represents the worst-case scenario in that, for example, the screening effects of intervening trees, woodland and built development are not taken into account in the generation of the ZTV's. Consequently, in many instances, the visibility of the development as shown on the ZTV's does not in reality exist.

Based on the above information, the nature or the magnitude of change associated with the development was determined by combining judgements about matters such as the size and scale of the change, the extent of the area over which it occurs, whether it is reversible or irreversible and whether it is short, medium or long term in duration.

Based on these criteria, the aspects as they relate to the future development at Gaens Quarry has been assessed:

The size and scale of the effect

The main landscape effects will be associated with:

- The removal of the quarry tip that forms a skyline feature to the southeast of the quarry within the short to medium terms (5-10 years).
- The lateral extension of the quarry extents to the west into the currently wooded scarp edge.
- The removal of areas of naturally regenerated vegetation and/or woodland around the periphery of the existing site associated with former quarry faces and benches either associated with the lateral extension or infilling of the former western quarry void.

With regards to the removal of the existing quarry tip, this will be generally associated with the removal of the generally unvegetated top and inner slopes to enable the lateral expansion of the quarry in the southeastern corner of the site. In relation to the western lateral extension, the extraction boundary extends into the adjacent wooded ridgeline down towards Lamb Row, only being some 20m way from the nearest property located along this road (Rock Cottages). However, it is expected the wooded lower outer slopes will remain, in conjunction with the wooded slopes to the west, which maintains the overall visual wooded nature of the site boundary in proximity to the Heol y Splot valley and the South Cornelly conurbation. However, from a distance the removal of this tip, which while being beneficial in terms of removing an unsightly skyline feature, may in conjunction with the western lateral extension, also open up the upper sections of the active northern/eastern backfaces to view from further afield.

In relation to the loss of small areas of naturally regenerated vegetation/woodland around the northern and western periphery of the existing site (both the ROMP and IDO areas), the total currently disturbed area associated with Gaens Quarry (including the Pant Mawr area), totals some 17.36ha.of which some 3.35ha. has either regenerated naturally or is in the process of doing so, excluding woodland associated with the southern and southwestern boundaries. The area of natural regeneration that will potentially be lost covers some 1.67ha. which equates to some 49.8% of the regenerated area, or some 9.6% of the total disturbed area.

In addition to the above, the southwestern woodland that lies within the ROMP boundary, but outside the currently disturbed area that will also be affected by the development, equates to some 0.9ha. This therefore means that a total 2.57ha. of existing natural regenerated vegetation/woodland will be lost.

The overall scale of effect of the future development relating to the lateral extension and deepening of the quarry void within the confines of existing/permitted site boundary has been assessed as **Small** (*adverse*) within the site, **Very Small** (*adverse*) in proximity to the site and **Very Small** (*beneficial*) further afield or elsewhere.

The geographical extent of the area that will be affected

The total area of the ROMP Review area totals some 12.26ha. The future quarry workings, which fall wholly within this area, totals some 10.5ha.,the majority of which has been previously disturbed apart from the wooded scarp slope which totals some 0.9ha. The remaining 1.76ha.is either currently disturbed, has naturally regenerated, or is partly associated with the void within Pant Mawr Quarry. As described above the remaining disturbed areas falls within the IDO area and future disturbance within this area is generally related to infilling with quarry waste to restore this area in the medium to longer term.

The main existing quarry tip also falls within the ROMP area and future proposals include for the substantive removal of this tip as part of the lateral extension to the south. As described earlier, this tip is the most prominent feature of the existing development that is visible as an unnatural skyline feature to landscape and visual receptors to the west and southwest of the site. The removal of this skyline feature in the short to medium term (5-10 years) will therefore be generally beneficial in nature. However, some adverse effects may also occur, such as the potential removal of some naturally regenerating areas/existing woodland, as well as potentially opening up to view from the west/southwest the upper sections of some of the back faces following its removal in conjunction with extraction within the western extension.

Due to the location of the quarry on the edge of an upland plateau with the future workings abutting this plateau area, plus woodland cover and hedgerows/tree belts to the majority of the quarry perimeter, the geographical extent of the area where the landscape or visual amenity is either affected by the current operations or the future extraction area, is generally limited to relatively small geographical areas to the west or southwest.

At Site level, the assessed geographical extent of the area that will be directly affected by the future development is therefore **Small** (*adverse*). The assessed geographical extent of the area that will be indirectly affected by the future development beyond the site boundary is therefore **Small** (*adverse*)in proximity to the site and **Very Small** (*beneficial*)further afield or elsewhere.

The duration of the effect and its reversibility

Although the effect of both quarrying and loss of the pre-existing landform is permanent, the restoration scheme allows for the partial infilling with inert materials, plus the subsequent infilling of the deep void with water thereby reducing the overall size of the quarry void and the boundaries becoming more naturalistic and in keeping with the scale of the surrounding landscape.

The operational life of the proposed development has therefore been assessed as being **Long Term** in nature (i.e. more than 15 years), with the effects generally **Permanent** in nature.

Overall Magnitude of Effect

Based on the above assessments, *within the site perimeter*, the overall magnitude of effect associated with the size and scale, geographical extent and duration of the development during the operational life has been assessed as generally being **Minor** *adverse*. Following final restoration the development has been assessed as generally being **Low** *beneficial.*

Based on the above assessments, *beyond the site perimeter*, the overall Magnitude of Effect associated with the size and scale, geographical extent and duration of the development during the operational life has been assessed as generally being **Very Low** *adverse*immediately adjacent and up to 2km to the west and northwest of the site; **Low** *beneficial*at distances between 2-3km to the west and southwest; and **Very Low** *beneficial* or **Neutral** further afield to the southwest.

This is due to the removal of the main tip as a prominent unnatural skyline feature, with future workings generally obscured by the surrounding mature woodland. The main exception to this being associated with the continued tipping and progressive restoration of the western half of the quarry (IDO area) which, without additional mitigation may be visible to the west of the site.

Following final restoration the development has been assessed as generally being **Very Low** *beneficial* in proximity to the site following final restoration of the tip and removal of the weighbridge, offices and fitting shop etc., as well as completion of the tip within the western half of the site (IDO area) and **Neutral** further afield to the west, southwest or elsewhere.

Assessed Overall Significance of Landscape Effects

Based on the above judgements relating to the nature or sensitivity of the landscape receptors and the magnitude or nature of the effect on these receptors, the following section describes how these different aspects have been combined together to form a judgement of the development's Overall Landscape Significance of Effect.

Effects on Visual and Sensory Aspect Areas

Based on the magnitude of effect criteria as set out above and as explained within Appendix 5/2 of the Environmental Statement, the assessment process concluded that the development will give rise to a degree of landscape effects to both the Newton Down Visual and Sensory Aspect (direct) and to the adjacentPorthcawl HinterlandsVisual and Sensory Aspect (indirect) during the operational life of the development prior to mitigation (but including 'inbuilt' mitigation measures). Other Visual and Sensory Aspects that have been assessed as potentially receiving some level of indirect effects includeKenfig Burrows, Kenfig Sands and Newton Point.

These effects are generally associated with the presence of the existing tipforming a prominent skyline feature within the local landscape; formerquarry faces, or potentially new quarry faces following removal of the main quarry tip;future extraction of minerals and associated vehicle movements;progressive infilling with quarry waste within the former quarry void (IDO area) and the subsequent passive infilling of the quarry with water.

Effects within the confines of the site

The Landscape Assessment process concluded that *within the confines of the site*, the area only falls within the Newton DownVisual and Sensory Aspect, which being of **Medium** sensitivity and the magnitude of effect being **Minor** *adverse,* the proposed future development will cause **Minimal** *adverse* significance of effects to the landscape character of the Newton Down Visual and Sensory Aspect Area during the Operational period. Following final restoration the magnitude of effect being **Low** *beneficial*, combined with the Aspect being of **Medium** sensitivity,the proposed future development in the long term will cause **Very Slight** *beneficial* significance of effectsto this Visual and Sensory Aspect (ref Appendix 5.2 Table 8 and as reproduced below as Table 6.2).

Table 5-2: Significance of Impacts: Correlation of Nature of Effect with Nature of Landscape or Visual Receptors

			NATURE of the Landscape/Visual Receptor (Sensitivity)				
			Very High	High	Medium	Low	Very Low
NATURE of Effect (Magnitude)	Adverse	Very High	Severe	Major	Substantial	Notable	Moderate
		High	Major	Substantial	Notable	Moderate	Slight
		Medium	Substantial	Notable	Moderate	Slight	Very Slight
		Low	**Notable**	**Moderate**	**Slight**	**Very Slight**	**Minimal**
		Very Low	Moderate	Slight	Very Slight	Minimal	Negligible
		Minor	Slight	Very Slight	Minimal	Negligible	Negligible
	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral
	Beneficial	Very Low	Slight	Very Slight	Minimal	Negligible	Negligible
		Low	Moderate	Slight	Very Slight	Minimal	Minimal
		Medium	Moderate	Moderate	Slight	Very Slight	Very Slight
		High	Notable	Notable	Moderate	Moderate	Slight

Effects within a 2km radius of the site

The Landscape Assessment process concluded that *beyond the site perimeter*, but in close proximity to the Site (less than 2km), Newton Down and Porthcawl Hinterland V&S Aspectswill potentially experience landscape effects from the development.

Based on the Newton Downand Porthcawl Hinterland Visual and Sensory Aspects being of **Medium** sensitivity and the magnitude of effect in close proximity to the Site being **Very Low** *adverse,* the proposed future development will at most cause **Very Slight** *adverse* significance of effects to the landscape character of the Newton Downand Porthcawl Hinterland Visual and Sensory Aspect during the Operational period.Following final restoration the magnitude of effect being **Very Low** *beneficial*, combined with the Aspects being of **Medium** sensitivity, the proposed future development in the long term will cause **Minimal** *beneficial* significance of effectsto these Visual and Sensory Aspects.

Effects beyond a 2km radius of the site

The Landscape Assessment process concluded that *beyond the site perimeter*, at distances greater than 2km, Porthcawl Hinterland, Kenfig Burrows, Kenfig Sands, and Newton Point V&S Aspects,as well as Kenfig Burrows and Porthcawl Coast SLAwill potentially experience landscape effects from the development.

Based on the Porthcawl Hinterland Visual and Sensory Aspect being of **Medium** sensitivity and the magnitude of effect at distances greater than 2kmfrom the Site to the west being **Very Low** *beneficial,* the proposed future development will at most cause **Minimal** *beneficial* significance of effects to the landscape character of the Porthcawl Hinterland Visual and Sensory Aspect during the Operational period.Following final restoration the magnitude of effect being **Neutral**, combined with the Aspect being of **Medium** sensitivity, the proposed future development in the long term will cause **Neutral** significance of effectsto thisVisual and Sensory Aspect.

Based on the Kenfig Burrows,Kenfig Sandsand Newton PointVisual and Sensory Aspectsbeing of **High** sensitivity and the magnitude of effect at distances greater than 2km from the Site to the west being **Very Low** *beneficial,* the proposed future development will at most cause **Very Slight** *beneficial* significance of effects to the landscape character of the Kenfig Burrows, Kenfig Sandsand Newton Point Visual and Sensory Aspectsduring the Operational period.Following final restoration the magnitude of effect being **Neutral**, combined with the Aspects being of **High** sensitivity, the proposed future development in the long term will cause **Neutral** significance of effects to these Visual and Sensory Aspects.

Based on the Kenfig Burrows SLA being of **High** sensitivity and the magnitude of at distances greater than 2km from the Site to the west being **Very Low** *beneficial,* the proposed future development will at most cause **Very Slight** *beneficial* significance of effects to the landscape character of the Kenfig Burrows SLAduring the Operational period.Following final restoration the magnitude of effect being **Neutral**, combined with the Aspects being of **High** sensitivity, the proposed future development in the long term will cause **Neutral** significance of effects to this SLA.

Based on the Porthcawl Coast SLA being of **Medium** sensitivity and the magnitude of at distances greater than 2km from the Site to the west being **Very Low** *beneficial,* the proposed future development will at most cause **Minimal** *beneficial*significance of effects to the landscape character of the Porthcawl Coast SLA during the Operational period.Following final restoration the magnitude of effect being **Neutral**, combined with the Aspects being of **Medium** sensitivity, the proposed future development in the long term will cause **Neutral** significance of effects to this SLA.

A summary of these findings are listed in Tables 5.3 and 5.4 below.

Table 5-3 Summary Overall Significance of Effects during the Operational Stage (Adverse unless otherwise stated)

Name (Visual and Sensory Aspect or SLA)	Assessed Landscape Sensitivity	Assessed Magnitude of Effect (Operational Stage)	Assessed Overall Significance of Effect (Operational Stage)
Within the Site			
Newton Down	Medium	Minor	Minimal
Beyond Site Perimeter - In Proximity to the Site <2km			
Newton Down	Medium	Very Low	Very Slight

Name (Visual and Sensory Aspect or SLA)	Assessed Landscape Sensitivity	Assessed Magnitude of Effect (Operational Stage)	Assessed Overall Significance of Effect (Operational Stage)
Porthcawl Hinterland	Medium	Very Low	Very Slight
Beyond Site Perimeter - Distance to the Site >2km			
Porthcawl Hinterland	Medium	Very Low (beneficial)	Minimal(beneficial)
Kenfig Burrows	High	Very Low (beneficial)	Very Slight(beneficial)
Kenfig Sands	High	Very Low (beneficial)	Very Slight(beneficial)
Newton Point	High	Very Low (beneficial)	Very Slight(beneficial)
Kenfig Burrows SLA	High	Very Low (beneficial)	Very Slight(beneficial)
Porthcawl Coast SLA	Medium	Very Low (beneficial)	Minimal(beneficial)

NOTE: The above table shows expected significance of effects following removalof the southern quarry tip,potentially opening up some back faces to view, as well as tipping within the western void,without additional mitigation associated with screen bunding, tree palnting etc.

Table 5-4 Summary Overall Significance of Effects Following Final Restoration (Beneficial)

Name (Visual and Sensory Aspect or SLA)	Assessed Landscape Sensitivity	Assessed Magnitude of Effect (Operational Stage)	Assessed Overall Significance of Effect (Operational Stage)
Within the Site			
Newton Down	Medium	Low	Very Slight
Beyond Site Perimeter - In Proximity to the Site <2km			
Newton Down	Medium	Very Low	Minimal
Porthcawl Hinterland	Medium	Very Low	Minimal
Beyond Site Perimeter - Distance to the Site >2km			
Porthcawl Hinterland	Medium	Very Low	Minimal
Kenfig Burrows	High	Very Low	Very Slight
Kenfig Sands	High	Very Low	Very Slight
Newton Point	High	Very Low	Very Slight
Kenfig Burrows SLA	High	Very Low	Very Slight
Porthcawl Coast SLA	Medium	Very Low	Minimal

In relation to landscape effects in the long term, following final restoration of the site including removal of all built structures, upper face and bench restoration, maturity of the proposed peripheral tree and hedgerow planting, as well as infilling the main quarry void with water, have been assessed as being all *beneficial* in nature. See Section 5.7 below 'Residual Landscape Impacts' relating to Landscape Effects after mitigation.

5.5 Visual Assessment

5.5.1 Identification of Visual Receptors

As described above a total of four ZTV's were produced to ascertain the potential visual envelope of both the current situation as well as that of the proposed future development in context to Gaens Quarry, as well as Cornelly and Grove Quarries. These studies, verified and updated by field work, concluded that due to the presence of strong mature woodland blocks associated with the central valley feature and the western southwestern perimeters of the site, plus the location and orientation of the quarry faces restricts the magnitude of visual effectsorientated to the west and southwest towards the lower lying agricultural fields between South Cornelly, north Porthcawl (Nottage), Sker Rocks and Sker Court between 1.0 - 3.0km from the site.

Immediately to the west, due to the rising landform and the presence of mature woodland around the majority of the site and in particular the western and southwestern scarp slopes, visual receptors in close proximity to the site (100-200m) do not receive direct visual effects associated with the presence of the southern tip, or previously worked quarry faces, although are likely to experience indirect effects associated with vehicle movements to and from the quarry joining onto the Porthcawl Road within the centre of South Cornelly and the northern roundabout with A4229 Pyle Road.

Further to the west, views progressively open up to include the upper sections of the southern waste tip and northeastern quarry faces. Due to the location of the current processing facilities set down within the quarry, in conjunction with the main valley feature associated with Hoel-y-Splot Road, views of the built structures associated with the wreighbridge, offices and workshop are generally restricted to adjacent the quarry entrance on Porthcawl Road.

Field work undertaken concluded that visual receptors could be categorised into two main zones (Zones 1 to 2).

Zone 1 is associated with receptors that gain views towards the site from less than 0.5km from the western site perimeter within the Newton Down plateau and the site entrance to the west. These receptors include:

- Residents within South Cornelly and users of the Porthcawl Road and other minor roads within the settlement.
- Users of Hoel-y-Splot Road adjacent to the Cornelly and Grove Quarries site entrance,sections of the A4229 and Porthcawl Road in proximity to the roundabout and the site boundary, plus the local footpath network within 0.5km of the site;
- Receptors that work within the South Cornelly Trading Estate that gain access from Hoel-y-Splot Road, including the Esso Petrol Station.

Zone 2 is associated with receptors that gain views towards the site from the west/southwest between 0.5-2.0km of the site, although longer distance views may be possible from up to 4.0km away. These receptors include:

- Users of the A4229 by-pass in the vicinity of South Cornelly;
- Users of the HeolDrewi, West Road and Heol-y-Broom road and the local footpath network within 2km of the site.
- Users of the Pyle and KenfigGolf Club, as well as Penymynydd Country Club/Sandville Court;
- Users of the various local footpath networksand public open space greater than 2km from the site including the Wales Coastal Path, Kenfig Sandsand Sker Point.
- Various isolated dwellings, farmsteads and caravan parks within the locality, includingSker Court, Westerleys, Pentwyn, Penycae, Waun-y-mer, Sker Cottages,Ty’r-ychen, Sker House, Kenfig Caravan Park, plus various unnamed dwellings;

5.5.2 Visual Magnitude of Change

The magnitude of change assessment work undertaken above associated with landscape effects, formed the basis for further work undertaken to inform the magnitude of change associated with visual receptors.

As described earlier, the proposed full quarry development is either contained within the currently disturbed area to the east, or the western section extending into the woodland along the adjacent ridge and scarp slope.This extension only extends into the ridge and does not affect the outer scarp slope and as such future faces are physically and visually contained within the wooded scarp slope. Desktop and field work has confirmed that this extension area lies beyond the visual ridgeline which precludes views of this area from receptors to the west and southwest.

Therefore, potential visual effects associated with the full quarry development in the medium term and beyond will not be dissimilar to those that currently exist except for the removal of the southern tip which currently forms a prominent skyline feature, plus potentially opening some back faces to view following tip removal, as well as later in the development when the western extension is worked. Other differences are potentially associated with the partial infilling with quarry waste sections of the western quarry void (IDO area) that have become partially overgrown with naturally regenerated vegetation. This cover has to a degree helped to partially mitigate views into the site from certain locations in close proximity to the site boundary. The loss of this cover, in conjunction with areas becoming an active tip closer to the site boundary will potentially open up the quarry to additional views to the west and northwest.

In terms of visual effects from the west, the majority of these impacts are associated with views of the existing southern quarry waste tip or upper sections of former quarry faces which partly stands out from the dark green of the surrounding woodland blocks. These faces,are likely to be partially backfilled with quarry waste and progressively restored during the life of the development.

The visual magnitude of change for the development is based on these visual studies undertaken prior to any offset by the implementation of the proposed mitigation measures as described in Section 5.6 below. The visual significance of effect tables list out the assessed sensitivity of individual receptors and/or groups of receptors, as well as the perceived magnitude or level of change. These textual values are then shown combined to arrive at the unmitigated significance of effect the existing and proposed development at Gaens Quarry will cause to the surrounding visual receptors.

5.5.3 Overall Visual Significance of Effects

Based on judgements relating to the nature or sensitivity of visual receptors most likely affected by the existing and proposed future development and the assessed magnitude, or nature of the effect on these receptors, the following section describes how these different aspects have been combined together to form a judgement of the development's Overall Visual Significance of Effect.

Based on the magnitude of effect criteria as set out in Sections 5.2.5 and as explained within Appendix 5/2, the assessment process as described above concluded that the development will give rise to a limited degree of visual effects to the surrounding receptors, especially to the north east and south, with the majority of adverse effects arising to the west and southwest generally associated with views of previously worked quarry faces and the existing southern quarry waste tip.

As listed in Section 5.5.1 above, the visual receptors identified as potentially receiving some level of effect have been grouped into the two visual assessment zones as identified above, for ease of analysing the different significance of effects caused by the existing and proposed development at Gaens Quarry on the visual amenity of the locality.In addition, the visual assessment process has identified that there will be differences in the level, or magnitude of effect in the short-medium term (5-10 years) and the longer term (+15 years). These differences relate to the removal of the southern tip in the short-medium term, followed by tipping operations and potentially opening the back faces to view in the longer term. A summary of these findings as well as these differences are illustrated within Tables 5.5 and 5.6 below.

Table 5-5 Summary of Significance of Effect on Visual Receptor Groups within Zone 1 during the Operational Stage (Adverse unless otherwise stated)

Principal Potential Receptors Include:	Nature of View	Sensitivity	Magnitude of Impact	Visual Impact Significance
Receptor Groups associated with Isolated Dwellings and farmsteads				
n/a				
Receptor Groups associated with Settlements including Public Open Space				
Various dwellings within South Cornelly	Views of the main access road into the site and associated traffic movement plus partial views of offices, weighbridge and workshop throughout the development. Relatively open if somewhat confined, restricted close distance views of the upper sections of former quarry faces in the short to medium term and tipping operations in the medium to long term.	High	Very Low (Short-Medium Term)	Slight
		High	Low (Medium-Long Term)	Moderate
Receptor Groups associated with Businesses				
Receptors that work within the South Cornelly Trading Estate that gain access from Hoel-y-Splot Road, including the Esso Petrol Station	Views of the views of the area of the southern quarry tip and relatively open if somewhat confined, restricted close distance views of the upper sections of former quarry faces in the short to medium term and tipping operations in the medium to long term.	Very Low	Very Low (Short-Medium Term)	Negligible
		Very Low	Very Low (Medium-Long Term)	Negligible
Receptor Groups associated with Visitors to Promoted Landscapes				
n/a				
Receptor Groups associated with other Transient Visitors (outside of promoted landscapes)				
Users of the footpath network to the south of the quarry that links South Cornelly with Heol y Splot road and further to the east.	Partially obscured views of the area of the southern quarry tip in the short term. Partially obscured views of Phase 4 workings when it breaks through into Pant Mawr in the longer term.	Medium	Minor (Short-Medium Term)	Minimal
		Medium	Very Low (Medium-Long Term)	Very Slight
Users of Porthcawl Road within South Cornelly and other minor residential roads	Views of the main access road into the site and associated traffic movement plus partial views of offices, weighbridge and workshop throughout the development. Relatively open if somewhat	Medium	Very Low (Short-Medium Term)	Very Slight

Principal Potential Receptors Include:	Nature of View	Sensitivity	Magnitude of Impact	Visual Impact Significance
	confined, restricted close distance views of the upper sections of former quarry faces in the short to medium term and tipping operations in the medium to long term.	Medium	Low (Medium-Long Term)	Slight
Users of the western section of Heol-y-Splot Road (a closed road) and sections of the A4229 and Porthcawl Road in proximity to the roundabout.	Road used as main quarry access to Cornelly and Grove with partially obscured views of the southern tip area and of the vegetated slope along southwestern boundary.	Medium	Very Low (Short-Medium Term)	Minimal
		Medium	Very Low Beneficial (Medium-Long Term)	Minimal Beneficial

Table 5-6 Summary of Significance of Effect on Visual Receptor Groups within Zone 2 during the Operational Stage (Adverse unless otherwise stated)

Principal Potential Receptors Include:	Nature of View	Sensitivity	Magnitude of Impact	Visual Impact Significance
Receptor Groups associated with Isolated Dwellings and farmsteads				
Various isolated dwellings and farmsteads within the locality, including, Sker Court, Westerleys, Pentwyn, Penycae, Waun-y-mer, Sker Cottages plus various unnamed dwellings	Relatively open if somewhat confined, restricted and medium distance views of the southern tip area in the short to medium term. Restricted and partial views of the upper sections of new quarry faces which may partly stand out from the dark green of the surrounding woodland blocks and tipping operations in the medium to long term. (1000-2100m).	High	Very Low (Short-Medium Term)	Slight
		High	Minor (Medium-Long Term)	Very Slight
Isolated dwellings and farmsteads within the locality, including Ty'rychen and Sker House.	Relatively open if somewhat confined, restricted and long distance views of the existing southern tip area in the short to medium term. Restricted and partial long distance views of the upper sections of new quarry faces which may stand out from the dark green of the surrounding woodland blocks in the medium to long term (2500m).	High	Minor (Medium-Long Term)	Very Slight
		High	Very Low Beneficial (Medium-Long Term)	Very Slight Beneficial
Various caravan parks within the locality, including Kenfig Caravan Park.	Relatively open if somewhat confined, restricted and long distance views of the existing southern tip area in the short to medium term. Restricted and partial long distance views of the upper sections of new quarry faces which may stand out from the dark green of the surrounding woodland blocks in the medium to long term (1500-2800m).	High	Minor (Medium-Long Term)	Very Slight
		High	Very Low Beneficial (Medium-Long Term)	Very Slight Beneficial
Receptor Groups associated with Settlements including Public Open Space				

Principal Potential Receptors Include:	Nature of View	Sensitivity	Magnitude of Impact	Visual Impact Significance
Various dwellings within the northern section of Porthcawl (Nottage)	Relatively open if somewhat confined, restricted and long distance views of the existing southern tip area in the short to medium term. Restricted and partial long distance views of the upper sections of new quarry faces which may stand out from the dark green of the surrounding woodland blocks in the medium to long term (1500-3000m).	High	Minor (Medium-Long Term)	Very Slight
		High	Very Low Beneficial (Medium-Long Term)	Very Slight Beneficial
Receptor Groups associated with Businesses				
Users of the Pyle and Kenfig Golf Club/ Course , as well as Penymynydd Country Club/Sandville Court	Relatively open if somewhat confined, restricted and medium distance views of the southern tip area in the short to medium term. Restricted and partial views of the upper sections of new quarry faces which may partly stand out from the dark green of the surrounding woodland blocks and tipping operations in the medium to long term. (1200-2500m).	High	Very Low (Short-Medium Term)	Slight
		High	Minor (Medium-Long Term)	Very Slight
Receptor Groups associated with Visitors to Promoted Landscapes				
Users of the various local footpath networks and public open space greater than 2km from the site including the Wales Coastal Path, Kenfig Sands andSker Point	Relatively open if somewhat confined, restricted and long distance views of the existing southern tip area in the short to medium term. Restricted and partial long distance views of the upper sections of new quarry faces which may stand out from the dark green of the surrounding woodland blocks in the medium to long term (2000-4000m).	Very High	Minor (Medium-Long Term)	Slight
		Very High	Very Low Beneficial (Medium-Long Term)	Slight Beneficial
Receptor Groups associated with other Transient Visitors (outside of promoted landscapes)				
Users of the local footpath network (due west of the site)	Relatively open if somewhat confined, restricted and medium distance views of the southern tip area in the short to medium term. Restricted and partial views of the upper sections of new quarry faces which may partly stand out from the dark green of the surrounding woodland blocks and tipping operations in the medium to long term. (500-2500m).	Medium	Very Low (Short-Medium Term)	Very Slight
		Medium	Minor (Medium-Long Term)	Minimal

Principal Potential Receptors Include:	Nature of View	Sensitivity	Magnitude of Impact	Visual Impact Significance
Users of the southern section of the B4283 Porthcawl/Pyle Roads and the A4229 by-pass in the vicinity of South Cornelly	Views of the views of the area of the southern quarry tip and relatively open if somewhat confined, restricted relatively close distance views of the upper sections of former quarry faces in the short to medium term and tipping operations in the medium to long term. (500-800m)	Medium	Very Low (Short-Medium Term)	Very Slight
		Medium	Very Low (Medium-Long Term)	Very Slight
Users of the central sections Heol Drewi, West Road and Heol-y-Broom road due west of the site	Views of the views of the area of the southern quarry tip and relatively open if somewhat confined, restricted relatively close distance views of the upper sections of former quarry faces in the short to medium term and tipping operations in the medium to long term. (500-2000m)	Medium	Very Low (Short-Medium Term)	Very Slight
		Medium	Very Low (Medium-Long Term)	Very Slight

In relation to visual effects in the long term, following final restoration of the site, including removal of all built structures, upper face and bench restoration, maturity of the proposed peripheral tree and hedgerow planting, as well as infilling the main quarry void with water, have been assessed as being all *beneficial* in nature. See Section 5.7 below 'Residual Visual Impacts' relating to Visual Effects after mitigation.

5.5.4 Viewpoint Photographs

A site visit was undertaken in December 2013, in good weather conditions and good visibility. A selection of these panoramic photographic, taken from various locations within the Study Area, are included as 'aide memoir" photographs in Figure 6.10 of Appendix 5/1.

5.5.5 Viewpoints

The viewpoints as included within this report are located within Appendix 5/2. A total of eleven panoramic photographs have been included. A brief description of these viewpoints is given below.

Viewpoint 1 - Looking east from Heol Drewi towards the Gaens, Cornelly and Grove Quarry complex.

This panorama shows the southern tip associated with Gaens Quarry which forms a skyline feature and the woodland block associated with the outer western slopes of Grove Quarry, plus the valley feature associated with Heol-y-Splot road. The chimney and buildings in the centre of the panorama is associated with the South Cornelly Industrial Estate.

Viewpoint 2 - Looking south-east from Heol Broom road towards the Gaens, Cornelly and Grove Quarry complex.

This panorama shows the top of the Gaens tip which is just visible above the tree line to the right of the telegraph pole. Old faces associated with Gaens quarry are also visible to the left of the photograph. The main partly worked southern and southeastern faces associated with Grove Quarry, with the recycling tip to the south of Heol-y-Splot road, form a large visually distinctive area within the centre of the photograph.

Viewpoint 3 - Looking north-east from the junction of Heol Dewi and the A4229 towards Gaens and Grove Quarry complex.

This panorama is looking from the A4229 with Heol-y-Splot road junction (main access road into Cornelly and Grove Quarries) to the right of the petrol station in the foreground and South Cornelly Trading Estate in the background behind which the southern tip of Gaens Quarry is visible. The woodland block to the right forms the western boundary to Grove Quarry.

Viewpoint 4 - Looking West along Mt. Pleasant Road towards Gaens and Grove Quarries.

This panorama shows the southern boundary to Cornelly Quarry to the right, with the agricultural field associated with the eastern extension to Grove Quarry in the distance (behind van) with Gaens Quarry hidden behind the far woodland belt.

Viewpoint 5 - Looking northeast from Mount Pleasant Road over Grove Quarry IDO Area towards Cornelly Processing Plant and Woodland adjacent to Gaens Quarry.

This panorama looks north west towards Gaens Quarry with only the tree block associated with Old Ballas Wood and vegetation around Pant Mawr visible across the agricultural fields associated with the future eastern extension to Grove Quarry (IDO permission). The upper sections of part of the large scale processing plant located within the western section of the Cornelly Quarry void are to the right of the photograph.

Viewpoint 6 - Looking north-west from Mount Pleasant Road on the south-eastern boundary of Cornelly Quarry with views towards Pant Mawr and Old Ballas Wood adjacent to Gaens Quarry.

This panorama looks north west with the location of Gaens Quarry to the far left with only the tree block associated with Old Ballas Wood and vegetation around Pant Mawr visible. In the foreground can be seen the active northern faces associated with Cornelly Quarry and the internal access road with the processing facilities set within part of the quarry void.

Viewpoint 7 - Looking west from Mount Pleasant Road on the eastern boundary of Cornelly Quarry into the main quarry void and processing facilities towards Pant Mawr and Old Ballas Wood adjacent to Gaens Quarry.

This panorama looks west with the location of Gaens Quarry in the distance with only the tree block associated with Old Ballas Wood and vegetation around Pant Mawr visible. Partly worked faces to the northeast of the Cornelly void and the partly flooded floor of the quarry are in the foreground, with the processing facilities in the middle ground.

Viewpoint 8 - Looking south towards the northern boundary of Pant Mawr and Old Ballas Wood which formm the northern boundary of Gaens Quarry immediately to the north of the M4 corridor (in cutting).

This panorama shows the undulating landform and woodland blocks that form part of the northern boundary to Pant Mawr/Cornelly Quarry complex and the northern boundary of Gaens Quarry associated with Old Ballas wood.

Viewpoint 9 - Looking east from Pyle & Kenfig Golf Course towards the Gaens, Grove and Cornelly Quarry complex.

This panorama shows the western and southern scarp slopes of Newton Down with the large tip associated with Gaens Quarry forming a skyline feature to the left; the extensive partly worked faces and recycling tip associated with Grove Quarry to the right; and the upper sections of the processing structures of Cornelly Quarry forming a skyline feature (the partly worked eastern quarry face behind these structures). The South Cornelly Industrial Estate is prominent in the middle distance.

Viewpoint 10 - Looking south-east from North Cornelly on Porthcawl Road towards the Gaens, Grove and Cornelly Quarry complex.

This panorama shows the undulating landform and woodland blocks (Old Ballas) that form the northern boundary to Gaens and Pant Mawr/Cornelly Quarry. The lower lying land associated with Heol-y-Splot road and the adjacent Grove Quarry complex are hidden from view by the intervening built development to the right of the photograph.

Viewpoint 11 - Looking east from Sker Point on Wales Coast Path towards the Gaens, Grove and Cornelly Quarry complex.

This panorama shows the western and southern scarp slopes of Newton Down with the large tip associated with Gaens Quarry forming a skyline feature to the left; extensive partly worked faces and recycling tip associated with Grove Quarry to the right; and the upper sections of the processing structures of Cornelly Quarry partly forming a skyline feature (with the partly worked eastern quarry face behind these structures). The South Cornelly Industrial Estate is prominent in the middle distance and the water tower and buildings associated with the old airfield (now the Stormy Down Research and Production Centre) forming a prominent skyline feature behind the processing plant.

5.6 Mitigation measures

As described previously, the existing quarry void is located on the edge of a broad upland plateau area, with levels ranging between 40m and 80m AOD. The eastern boundary of the site abuts the former Pant Mawr Quarry void, which forms part of the wider Cornelly and Grove Quarry complex.

The western and southwestern boundaries are formed either by an agricultural field or by a rising wooded scarp slope that falls away from the easement around previously worked faces or the large southern tip. The southern boundary of the site falls away into the valley feature associated with Heol-y-Splot road after which the landform rises again to form part of either the existing or proposed future workings associated with Grove Quarry. The northern boundary of the site consists of woodland or treebelts that either form a small isolated hillock which falls away more steeply as a localised scarp slope in proximity to Old Ballas Wood.

As a consequence the existing footprint of Gaens Quarry is generally well screened and enclosed by the existing landform and vegetation within the general landscape setting.

The future development includes the removal of the large and visually prominent tip on the southern boundary. This tip, as a 'built-in' mitigation measure, will be removed in the short to medium term (5-10 years). The proposed future extraction of minerals is generally confined to the currently disturbed area and includes extending laterally to the east south and west.

The southern lateral extension will occur in Phase 2, in the medium term, with the western and eastern extensions in the long term. The western lateral extension includes removing a small area of mature woodland associated with the edge of the scarp slope that falls away to the south/southwest. The eastern extension effectively removes the existing bluff that physically separates Gaens Quarry from the former Pant Mawr quarry void. This area includes areas that have naturally regenerated, which will be lost in the long term.

Future proposals also include for the partial infilling of the western half of the former quarry void with quarry waste (the IDO area) which is bounded to the north and south by woodland and tree belts. However, the raised nature of the area and the higher elevation of the back faces results on some of this area being relatively open to view to receptors to the west. This will also be the case when the area is partially infilled with quarry waste.

Desktop studies collaborated by field work has identified that these areas are visible to the west and northwest, mainly between 0.5-1.0km from the site. The visibility of this tip and former quarry faces are increased by the light colour of these areas set against a dark green vegetated backcloth.

The following mitigation measures proposed therefore take these factors into account.

- Ensuring the limits of quarrying within the ROMP area avoids opening up the quarry to views from the west that would significantly affect local landscape character.
- Retaining the higher northern faces that have not been worked for a number of years which have weathered, so that following removal of the southern tip, faces that potentially become exposed to view are limited to these faces.
- Retaining the wooded southern and eastern flanks that are either wooded or are partly vegetated through natural regeneration as long as possible within the development to reduce a possible increase in landscape and visual effects from receptors to the west.
- Construction of a naturalistic screening bund along the southern boundary of the IDO area early within the development to screen tipping operations and possible vehicular movements from view to the west. The bund to be grass seeded and planted with native trees and shrubs to provide a vegetated visual barrier to views both in the short and long terms.
- Infill, widening and strengthening of the woodland belt along the western boundary of the proposed quarry void (adjacent to Lamb Row and Rock Cottages as well as adjacent to the weighbridge and offices) to help provide an additional visual barrier to potential views of the site when the existing trees are felled and the area is worked and ensure the long term survival of this visually important hedgerow/treebelt.
- Removal/relocation of the current southern tip early within the development and restoration of the lower slopes that are to remain by infill planting with trees and shrubs.
- Progressive working and restoration of the upper faces/benches both within the eastern void (ROMP area), as well as the future tipping operations within the western quarry void as they reach final position by overtipping/natural recolonisation/tree and shrub planting/ grassland creation to create a more naturalistic landform and allow these areas to mature as early within the development as possible and minimise landscape and visual effects from receptors to the west.

5.7 Residual Impacts

5.7.1 Landscape Residual Impacts

The landscape appraisal concluded that *within the confines of the site*, the proposed future development will only cause **Minimal** *adverse* significance of effects to the landscape character of the Newton Down Visual and Sensory Aspect Area before mitigation during the Operational period, primarily due to the majority of the area already being disturbed, but also including the loss of areas that have naturally regenerated as well as the small area a mature woodland on the southwestern boundary.

The Landscape Assessment process also concluded that *beyond the site perimeter*, will at most cause **Very Slight** adverse significance of effects to the landscape character of the Newton Down, Porthcawl Hinterland, Kenfig Burrows, Kenfig Sands and Newton Point Visual and Sensory Aspects and Kenfig Burrows SLA during the Operational period.

The proposed mitigation measures include the removal, relocation and early restoration of the current large southern tip area, including the restoration of upper faces/benches and overburden slopes; the creation of a small perimeter screening bund; plus beating up, infilling, widening and strengthening the existing woodland/hedgerow alongside the western and southwestern boundaries.

In conjunction with the proposed progressive working and restoration of the upper faces/benches, it has been assessed, due to the overall timescales of the operational period that these measures will generally offset the predicted loss of vegetation cover/habitats in the longer term *within the confines of the site*. This is due to the fact that the eastern and western extensions are not expected to be worked for in excess of 20 years, which is enough time for the proposed peripheral planting and tip restoration to have reached some degree of maturity.

Therefore in landscape terms, following mitigation, *within the confines or in close proximity to the site*, the proposed future development will generally mitigate any *adverse* effects to the landscape character of the Newton Down Visual and Sensory Aspect Area during the Operational period. It is expected that this mitigation measure will reduce the maximum adverse effects from **Very Slight** or **Minimal** *adverse* to **Minimal** *beneficial.*

The level of landscape effects further to the west and southwest following mitigation (tip/face restoration, screen bunding and additional tree and shrub planting), will generally further reduce any potential overall adverse effects of these areas as either a prominent skyline feature or potentially becoming visible in the future. The predicted levels of effect from further afield to the west without additional mitigation has already been assessed as giving rise to low levels of *beneficial* effect (due to the removal/relocation of the southern tip as a prominent skyline feature). The effect of additional mitigation measures will therefore help to maintain these levels and prevent the development from causing any *adverse* effects in the future.

In addition, as the extent of progressive vegetation increases and a significant proportion of the vegetation reaches maturity over the predicted life of the development the level of beneficial effects will progressively increase once the processing plant has been removed and the quarry void infilled with water and other nature conservation and/or leisure activities potentially replace one industrial in nature.

5.7.2 Visual Residual Impacts

The visual appraisal concluded that receptors associated with settlements, isolated dwellings, leisure facilities and the surrounding road and footpath network, in particular those located to the west and southwest of the site, experienced up to **Moderate** *adverse* significance of effects before mitigation during the Operational period, primarily due to the relatively openness of the future tipping operations within the former western quarry void to view from these locations.

The proposed mitigation measures (screening bunding and tree and shrub planting) will reduce the overall effect of these areas as a prominent feature in close proximity to the site, but may not fully mitigate effects from slightly further afield, due to the height of the backfaces tipping area. It is expected that these mitigation measures will reduce the maximum adverse effects from **Moderate** *adverse* to either **Slight** *adverse* or **Very Slight** *beneficial.*

Again as a significant proportion of the proposed planting and natural regeneration reaches maturity over the predicted life of the development, the level of beneficial effects will progressively increase As relatively unnatural faces will always be visible (within the confines of the site), but their prominence and naturalist appearance set within a well wooded structure has been assessed as being *beneficial* once vegetation matures and the quarry void infills with water and other nature conservation and/or leisure activities potentially replace one industrial in nature

5.8 Cumulative Effects

5.8.1 Introduction

In addition to the landscape and visual appraisals associated with Gaens Quarry, a cumulative landscape and visual impact assessment has also been undertaken, to assess the cumulative effects the development may give rise to in light of other ongoing and/or future quarrying activities within the locality.

Cumulative Effects can be described as the additional changes caused by a proposed development in conjunction with other similar developments or as the combined effect of a set of developments, taken together.

This cumulative impact assessment therefore has looked at the existing and proposed development at Gaens Quarry in light of the existing and likely future developments at Cornelly Quarry, Grove Quarry and at Stormy Down Quarry. These three additional developments are all located within 1km of the site, effectively abutting the boundary of Gaens Quarry and therefore have the ability to increase the levels of the overall landscape and visual effects when assessed as a whole.

5.8.2 Cornelly Quarry

Cornelly Quarry is located immediately to the east of Grove Quarry and south of the former minor road of Heol-y-Splot which in the past has been worked concurrently with Grove. This currently forms the active section of the Cornelly/Grove complex. Access to the site is also via Heol y Splot road from the roundabout on the A4229.

As a consequence of the location of the quarry within the Newton Down upland plateau, in conjunction with the surrounding topographical features, Cornelly Quarry is generally well screened and enclosed by the existing landform and vegetation within the general landscape setting. However, the location of Mount Pleasant Road abutting the site to the south and east and the proximity of the quarry faces allows relatively open, if somewhat intermittent views both into the quarry void as well as the large structures associated with the processing plant. Again, due to the sloping landform to the west along with the presence of the central valley feature, these large structures also occupy a prominent skyline position from certain locations to the west of the site.

In terms of future development the proposals include both deepening and widening the existing quarry void over the remaining life. Therefore landscape and visual will be associated with reworking some of the existing backfaces, that are visible, to a final face configuration to maximise the width of the quarry prior to deepening. It is expected that these will be restored early within this period, with the remaining workings consisting of deepening the quarry that will not be visible outside the confines of the site following mitigation works adjacent to the southern and eastern boundaries of Mount Pleasant Road.

In addition the removal and/or relocation of the main structures of the plant site after some 25-30 years to the north away from the central valley feature at a similar, or lower floor level than as present for the remainder of the development period will help mitigate some of the landscape effects associated with the overall size and scale of these structures within the Newton Down V&S Aspect area.

Based on these findings, the assessment process concluded that cumulative landscape and visual impacts associated with Cornelly Quarry will generally be limited to three main areas. Namely:

- An area of land defined to the east by South Cornelly, to the north by the M4 and North Cornelly, to the south by Heol Drewi/Moor Road and the west by a section of the coast centred around Sker Point (for the next 15-20 years).
- A section of Mount Pleasant Road from Ty Coch Farm to the junction with Heol y Splot road to adjacent to Stormy Down Quarry.
- Quarry Traffic utilising the same access point as Grove Quarry on to the A4229.

The longer distant views to the west are only capable of being partly mitigated in the long term by the removal and/or relocation of the larger structures of the plant site to the north away from the central valley feature at a similar, or lower floor level than as present for the remainder of the development period.

The effects along Mount Pleasant Road can be fully mitigated by the proposed screening bund abutting the southern and eastern boundaries of the site, including hedgerow and woodland planting. In relation to quarry traffic, once Grove Quarry recommences operations there will be an increase in traffic onto the A4229 at the Heol y Splot roundabout, but being a busy road, with HGV traffic associated with the neighbouring industrial estate, this increase is not likely to be significant in landscape or visual terms.

5.8.3 Grove Quarry

Grove Quarry is located immediately to the west of Cornelly and south of Heol y Splot, which in the past has been worked concurrently with Cornelly, although at present is not being actively worked. Access to the site is via Heol y Splot road from a point just east of the roundabout on the A4229. The area associated with the plant site is currently being utilised as a recycling facility, which consists of low level plant or industrial buildings that are set at a lower level within the confines of the quarry, surrounded by faces and dense vegetation. The activities thus do not intrude on or adversely affect the surrounding landscape or visual amenity.

Currently, the former faces that rise eastwards into the plateau area are generally hidden from most areas, but the upper areas do become highly visible from the northwest between South Cornelly and Pyle and Kenfig Golf Club. In addition to these old faces, which are now generally weathered, blending in with the surroundings, another recycling operation appears to be utilising a small section of the northern quarry void to tip recycled material onto the applicants land, which is very visible from these locations. It is expected that this operation will be stopped and the tip removed in the short term, allowing the area to be restored.

In terms of future development the proposals include deepening the existing quarry void over the next 15 year period, prior to extending the faces eastwards towards Cornelly Quarry during the remaining permitted life.Therefore landscape and visual effects over the next 15 years that occurs concurrently with the Cornelly development, will be associated with reworking some of the existing back faces, that are visible, to a final face configuration to maximise the width of the quarry prior to deepening. It is expected that these will be restored early within this period, with the remaining workings consisting of deepening the quarry that will not be visible outside the confines of the site. It is also proposed that additional mobile processing facilities will be installed within the former plant site area, where recycling operations currently take place. This equipment is expected to be relatively low in profile and therefore should not be visible externally to the site.

5.8.4 Stormy Down Quarry

Stormy Down Quarry is located immediately to the north east of Cornelly Quarry with Mount Pleasant Road running along its southern boundary. A new link road between Mount Pleasant Road and Heol y Splot runs along the western boundary, and the A48 forms the north eastern boundary. Permitted reserves are substantially exhausted, and the quarry is partly flooded with the majority of former benches and faces generally revegetated through natural regeneration. The former plant site area is currently being utilised by a recycling company which has direct access onto the A48 Trunk Road. The western and southern boundaries to the site either consist of large, generally vegetated screening mounds or by a substantial hedgerow/tree belt. The quarry therefore is not visible from these locations, although the recycling unit abuts the northern boundary associated with the continuation of Heol y Splot after which it joins with theA48. No cumulative landscape or visual effects have been assessed as being associate with this quarry.

5.8.5 Cumulative Landscape Effects Conclusions

Based on the above findings cumulative landscape (and visual) impacts are generally limited to an area due west of the combined quarry areas and associated with the presence of the large processing facilities at Cornelly Quarry, old faces and current operations at Grove Quarry and previous or current tipping operations at Gaens Quarry. These aspects of the three developments act to substantially increase the extent of noticeable disturbance and due to their proximity to each other, visually appear to form a single large scale operation.

The landscape assessment process for Cornelly Quarry, found that to the west, the presence of the upper sections of parts of the large processing plant, where these often form a skyline feature during the next 25-30 years, gave rise to up to **Moderate** *adverse* levels of effect, either in proximity to the site, or further afield within designated areas.

The landscape assessment process for Grove Quarry found that to the west, *before mitigation*, the maximum adverse effects gave rise to up to **Moderate** *adverse* levels of effect, either in proximity to the site, or further afield within designated areas.

The landscape assessment process for Gaens Quarry found that to the west, *before mitigation*, the maximum adverse effects gave rise to up to **Moderate** *adverse* levels of effect, in proximity to the site.

When these levels for all three sites are combined, the cumulative landscape effects, *before mitigation*, were assessed as giving rise up to **Notable** *adverse* to the landscape character of the Newton Down, Porthcawl Hinterland, Kenfig Sands Visual and Sensory Aspects and Kenfig Burrows and Porthcawl Coast SLAs during the operational period in the medium to long term.

The landscape assessment process for Cornelly Quarry, found that *following mitigation* (removal and/or relocation of these structures to the north within the quarry void, between 25-30 years from now), will substantially reduce these adverse effects, although due to the unknown future configuration of the plant site, a detailed assessment has not been undertaken at this stage, but as a 'worse case' scenario, the current levels of effect could remain throughout the remaining life of the development.

The landscape assessment process for Grove Quarry found that to the west, *following mitigation*, (tip restoration and early face restoration), reduced the maximum adverse effects to **Slight** *adverse.*

The landscape assessment process for Gaens Quarry found that to the west, *following mitigation*, (tip restoration), reduced effects to **Minimal** *beneficial.*

.
When these levels for all three sites are combined, the cumulative landscape effects, *following mitigation*, were assessed as giving rise up to **Moderate** *adverse* levels of effect in the medium to long term, prior to the removal/relocation of the Cornelly processing plant and **Slight** *adverse* thereafter (assuming an overall reduction in effects following the removal/relocation of the plant site), during the remainder of the operational life to the landscape character of the Newton Down, Porthcawl Hinterland, Kenfig Sands Visual and Sensory Aspects and Kenfig Burrows and Porthcawl Coast SLAs.

In relation to cumulative landscape effects along Mount Pleasant Road, mitigation measures associated with both Cornelly and Grove Quarries includes the proposed construction of a 2.0m high screening bund alongside part of this road, in association with additional hedge and tree planting. These measures were found to fully mitigate adverse landscape effects in this location. Cumulative effects *following mitigation* were therefore found to be **Neutral** from this location.

5.8.6 Cumulative Visual Impacts Conclusions

As stated above, cumulative visual impacts are also generally limited to an area due west of the combined quarry areas and associated with the presence of the large processing facilities at Cornelly Quarry, old faces and current operations at Grove Quarry and previous or current tipping operations at Gaens Quarry, which act to substantially increase the extent of noticeable disturbance as well as visually appearing to form a single large scale operation.

The visual assessment process for Cornelly Quarry found that to the west, *before mitigation*, the presence of the upper sections of parts of the large processing plant, often forming a skyline feature, gave rise to up to **Moderate** *adverse* levels of effect in proximity to the site, or **Slight** *adverse* further afield towards the coast where receptors were assessed as being Very High in sensitivity.

The visual assessment process for Grove Quarry found that to the west, *before mitigation*, the maximum adverse effects gave rise to up to **Notable** *adverse* levels of effect in proximity to the site, or **Moderate** *adverse,* further afield towards the coast where receptors were assessed as being Very High in sensitivity.

The visual assessment process for Gaens Quarry found that to the west, *before mitigation*, the maximum adverse effects gave rise to up to **Moderate** *adverse* levels of effect in proximity to the site, or **Very Slight** *adverse* further afield towards the coast where receptors were assessed as being Very High in sensitivity.

When these levels for all three sites are combined, the cumulative visual effects *before mitigation*, were assessed as giving rise up to **Notable** *adverse* in proximity to the site, or

Moderate *adverse* further afield towards the coast during the operational period in the medium to long term.

The visual assessment process for Cornelly Quarry, found that *following mitigation* (removal and/or relocation of these structures to the north within the quarry void, between 25-30 years from now), will substantially reduce these adverse effects, although due to the unknown future configuration of the plant site, assessment has not been undertaken at this stage.

The visual assessment process for Grove Quarry found that to the west, *following mitigation*, (tip restoration and early face restoration), reduced the maximum adverse effects to **Slight** *adverse.*

The visual assessment process for Gaens Quarry found that to the west, *following mitigation*, (screen bunding and tree and shrub planting), reduced the maximum adverse effects to **Slight** *adverse* or **Very Slight** *beneficial.*

When these levels for all three sites are combined, the cumulative visual effects, *following mitigation*, were assessed as giving rise up to **Moderate** *adverse* levels of effect in the medium to long term, prior to the removal/relocation of the Cornelly processing plant. Although it is expected that these levels will be substantially reduced following removal/relocation of the Plant Site to the north, as a 'worse case' scenario, the current levels of effect could remain throughout the remaining life of the development.

In relation to cumulative visual effects along Mount Pleasant Road, mitigation measures associated with both Cornelly and Grove Quarries includes the proposed construction of a 2.0m high screening bund alongside part of this road, in association with additional hedge and tree planting. These measures were found to fully mitigate adverse landscape effects in this location. Cumulative effects *following mitigation* were therefore found to be **Neutral** from this location.

5.8.7 Summary of Cumulative Effects

For Gaens Quarry in isolation, the findings of the landscape and visual assessment process gives rise of up to Moderate levels of adverse effects to the west. However, in conjunction with the cumulative landscape and visual assessment for Cornelly and Grove Quarries, the overall landscape and visual assessment process found that the Gaens development, without mitigation, and in conjunction with developments at the other quarries gives rise to significant levels of adverse landscape and visual effects in the short and longer terms to the more highly sensitive receptors to the west.

However, allowing for mitigation associated with all three developments, for both landscape and visual receptors these levels reduce to Moderate adverse in the medium to long term and Slight adverse thereafter, during the remainder of the operational life.

In proximity to the site, especially along the western southwestern boundary, the findings of the landscape and visual assessment for Gaens Quarry found that without mitigation the development gives rise to Moderate adverse levels of effects. However, these levels were capable of being nearly fully mitigated in both the short and longer terms by the construction of a perimeter bund and associated tree and hedge planting.

5.9 Recommendations

Based on the potentially significant levels of both landscape and visual effects, it is recommended that the proposed mitigation measures proposed for Gaens, Grove and Cornelly Quarries be implemented early within the development. The measures as they relate to the introduction of additional areas of tree and shrub planting will not only improve the visual amenity of the areas, but will also enhance the biodiversity and conservation value of the areas in the medium to long term. A programme of landscape enhancement and management will also be drawn up and implemented to cover both existing hedgerow/woodland blocks within the confines of the site(s) throughout the remaining life of the development as well as the 5 year aftercare period.

5.10 Planning Conditions

In terms of landscape and visual matters the following key recommendations are suggested for inclusion within the ROMP Review to ensure the development meets current planning requirements and safeguards and enhances the areas landscape character and visual amenity both throughout the remaining operational life but also into the longer term following final restoration of the site.

- The Relocation and Restoration of the Existing Southern Tip and Restoration of the Retained Lower Slopes
- Formation of Screening Banks
- Proposed Hedgerow and Woodland Infilling and Planting
- Creation/Management, and Enhancement of Existing and Proposed Habitats in the Long Term

5.11 Conclusions

The landscape and visual assessment study utilised the Welsh LANDMAP GIS system to ascertain the character, quality, condition and generic sensitivity of the local landscape. This was undertaken primarily by analysing the Visual and Sensory Aspect of the LANDMAP datasets as it constitutes the main visual and landscape characteristics of the areas potentially affected by the development.

The generic sensitivity of the other four aspects as laid out within LANDMAP was also utilised in order to help form a judgment as to the overall sensitivity of the locality to the existing and proposed future development.

The study found that the site falls within the Newton Down Visual and Sensory Aspect. The assessment process concluded that this areas sensitivity, based on the type of development and its *susceptibility to change* and perceived *value,* results in a combined overall Medium Sensitivity to change.

An analysis of the existing and proposed future developments, which included both desktop studies and fieldwork, concluded that Gaens Quarry, in isolation only gives rise to Moderate levels of adverse effects to the west. However, in conjunction with the cumulative landscape and visual assessment for Cornelly and Grove Quarries, the overall landscape and visual assessment process found that these developments, without mitigation, gives rise to significant levels of adverse landscape and visual effects in the short and longer terms, especially to the more highly sensitive receptors to the west.

However, allowing for mitigation associated with all three developments, these levels reduce to Moderate adverse in the medium to long term and Slight adverse thereafter, for both landscape and visual receptors during the remainder of the operational life. Therefore together these levels do not give rise to significant levels of adverse effects to either sensitive receptors to the west or those in closer proximity to the site.

In conclusion therefore no landscape and nature conservation designations will be directly affected by the development and with mitigation along with progressive working and restoration, the site, in context to the surrounding landscape character and visual amenity, will see a marked improvement compared to current conditions with enhanced habitat provision and better integration with the surrounding landscape character, particularly those that have some form of designation.

Therefore, in overall terms, whilst potentially some significant effects are present without further mitigation, the implementation of the proposed mitigation measures, in associated with the location, orientation, level, scale and progressive nature of the development, means that both the character, setting and visual amenity of the local landscape will not be adversely affected to any significant degree in the medium and longer terms. Following final restoration the development should benefit and help strengthen the overall fabric and character of the local landscape.

5.12

6.0 ECOLOGY

6.1 Introduction

The study area was initially surveyed and assessed in detail by David Clements Ecology Ltd (DCE) in 2003, and was subsequently resurveyed in 2008 and 2013, using appropriate methods. The surveys were mainly based around the Extended Phase 1 survey methodology (see below), with some additional surveys for specific interests where these were considered necessary and practical.

Information in support of this assessment is included at Appendices 6/1 to 6/10.

In accordance with a request from the WG, a Shadow AA has therefore been carried out by Atmos Consulting Ltd in parallel to this EcIA, to assess the effects of the continued operation of Gaens Quarry in conjunction with Cornelly Quarry and the currently mothballed Grove Quarry on Kenfig SAC. This Shadow Appropriate Assessment is included at Appendix 6/9.

6.2 Approach and Methodology

The surveys on both occasions were constrained in some parts of the study area by the hazardous nature of the quarry faces and lagoons. Some steep and inaccessible areas could not be safely inspected other than at a distance.

6.2.1 Vegetation and Habitats

The study area was originally surveyed in July 2003, and was resurveyed during September 2008; the most recent survey was conducted on 25th June and 3rd July 2013. On all occasions, the Extended Phase 1 methodology recommended by the Institute of Environmental Assessment (IEA 1995) and the Chartered Institute of Ecology and Environmental Management (CIEEM 2012) were used. This was based on the Phase 1 vegetation classification developed by the former Nature Conservancy Council (NCC 1990), a nationally-accepted standard method for the rapid survey and appraisal of ecological habitats, which is based primarily on the recording of vegetation and its classification into defined habitat categories. Dominant and conspicuous flora species are recorded and ‘target notes’ are prepared for any features of particular interest. The methodology also requires the recording of conspicuous fauna species, such as birds, herptiles (ie amphibians and reptiles), mammals and invertebrates such as butterflies and dragonflies, paying particular attention to the presence (or possible presence) of any rare or protected species.

Where appropriate, the habitats of the site were also characterised against the descriptions provided by the National Vegetation Classification (NVC) as set out by Rodwell (1991 *et seq*).

Hedges were assessed for nature conservation significance using the Hedgerow Evaluation & Grading System (HEGS) of Clements & Tofts (1992), and were also assessed against the wildlife and landscape criteria of the Hedgerows Regulations 1997.

6.2.2 Birds

Wintering birds were initially surveyed by an experienced bird surveyor in good weather in February 2003. Due to the nature of the habitats and the comparatively low diversity and interest of the wintering bird fauna found at that time, it was not considered necessary to resurvey the wintering bird fauna in 2008 or 2013.

Breeding birds were surveyed by an experienced bird surveyor in good weather in April/May 2003, May/June 2008 and the most recent surveys were undertaken on 25th June, 3rd July and 7th August

2013. All accessible parts of the study area were walked and any birds were recorded together with an assessment of their probable breeding status based on evidence such as territorial behaviour (eg singing males), presence of pairs, nests, families or young, parents carrying food or nesting items etc (see Bibby *et al* 2000 for broad methodology).

6.2.3 Dormouse

Woodland and scrub areas were searched for signs of dormouse, and the habitat suitability for this species was assessed in accordance with the guidance currently provided by Bright *et al* (2006). Any hazelnuts showing signs of handling by small mammals were checked for evidence of dormouse. The early surveys were undertaken in July 2003 and October 2008, with the most recent surveys being undertaken on 25th June and 3rd July 2013.

6.2.4 Bats

Flight surveys were originally carried out in July 2003, September 2008 and October 2008; the latter date with the intention of surveying for autumn swarming. The most recent surveys were carried out on 4th July and 7th August 2013 in warm, dry and still conditions. The survey was carried out by two experienced bat surveyors using electronic bat detection equipment which included Pettersson D200 heterodyne bat detectors and Anabat SD1 frequency division detectors. Signals from the Anabat detectors were recorded to flashcards for subsequent study using AnalookW bat call analysis software. The surveys were carried out from approximately 20 minutes before dusk until well after nightfall. For safety reasons, survey was mainly confined to the upper rim and non-working areas of the quarries, where a transect methodology was adopted (see Appendix 6/10: Plan 3).

The site was originally surveyed for badger in 2003 and 2008; these surveys were repeated on 25th June and 3rd July 2013. All accessible parts of the study area were searched for signs of badger (eg setts, paths, dung pits, snuffle pits, scratched up turf, etc) following the broad guidance provided by Harris *et al* (1994) and Harris *et al* (1988).

6.2.5 Amphibians

Investigation of the larger quarry lagoons for amphibians was limited by safety considerations. The extant lagoons in July 2003 were all surveyed using a combination of 'lamping', using high-powered lanterns (CluLite CB1), during the period 4-8 July 2003, and one smaller lagoon was subject to survey using 'bottle traps' (see Griffiths & Inns1998). In the period since 2003, the layout, size and nature of the main quarry lagoons has altered considerably.

In 2008, bottle-trapping surveys were carried out in all of the extant lagoons of the site during the period 14-16 May 2008, timed to coincide with the main period of aquatic activity for great crested newt. Amphibian activity was also once again assessed via 'lamping' with high-powered lanterns (CluLite CB1), also during the period 14-16 May 2008. The water in the lagoons was moderately clear and afforded good visibility.

Given the lack of evidence of the rare and protected great crested newt (*Triturus cristatus*) in previous studies, and the general hazardous nature of the quarry, the 2013 study was limited to lamping of the extant lagoons with high-powered lanterns (CluLite CB1); this was undertaken on 4th July and 7th August 2013; weather conditions were warm, dry and still. The layout and size of the lagoons had again altered since the 2008 study (see (see Appendix 6/10: Plan 2)for location of the lagoons). A small temporary pool at the north of the site was also surveyed.

6.2.6 Reptiles

The site was subject only to a reconnaissance reptile survey in 2003. In 2008, full reptile surveys were undertaken during the September/October. Reptile surveys were also undertaken between

25th June and 21st August 2013 in accordance with the advice provided by Gent & Gibson (1998). This survey comprised the placing-out of approximately 50 'artificial refugia', comprising 60 x 60cm squares of roofing felt, to act as artificial roosting and basking sites. The refugia were placed-out in areas of the site which were assessed as being most likely to be attractive to reptiles, particularly in the longer grass at scrub margins (see Appendix 6/10: Plan 5) for refugia locations). These were then revisited at regular intervals in suitable weather conditions over the following weeks in order to record the species and numbers of any reptiles found underneath or on the refugia.

6.2.7 Data Trawl

In addition to the original surveys detailed above, previously existing data and records for the site were sought from the following conservation and data-holding bodies based in the region:

- South East Wales Biological Records Centre (SEWBReC)
- Bridgend County Borough Council (BCBC) Countryside Manager, Robert Jones

SEWBReC is now the main repository for ecological data and information in the region.

Existing data sources were also studied, including the CCW Phase 1 Survey of 1992-93 and the *Glamorgan Inventory of Ancient Woodland* (Sothern 1986).

6.3 Designated Sites

Designated sites of nature conservation and biodiversity interest are shown on (see Appendix 6/1: Plan 1). The quarry lies within an area of high ecological interest and there are a large number of statutory and non-statutory designated sites in the immediate vicinity.

6.3.1 Statutory Sites

The most significant statutory nature conservation sites in the vicinity are the ***Kenfig Special Area of Conservation*** (SAC), which covers two large and separate sand dune complexes at Kenfig and Merthyr Mawr, and the ***Cefn Cribwr Grasslands SAC*** which covers a group of four separate areas of grasslands. These areas enjoy the highest level of statutory protection available in the UK, being designated under the EC Directive on the Conservation of Natural Habitats of Wild Flora and Fauna 1992 (implemented in the UK via the Conservation (Natural Habitats etc) Regulations 1994) and are considered to have Europe-wide (ie international) conservation importance.

The sand dune complexes at Kenfig and Merthyr Mawr are also independently designated as National Nature Reserves (NNR), and both these and the four sites which make up the Cefn Cribwr Grasslands SAC are independently designated as Sites of Special Scientific Interest (SSSI). The SSSI and NNR designations reflect the highest level of UK-wide (ie national) importance and cover areas which extend outside of the SAC boundaries.

In addition there are three other SSSIs in the immediate vicinity, comprising ***Eglwys Nunydd Reservoir***, ***Waun Cimla*** and ***Stormy Down***. The latter comprises a cutting on the M4 motorway and some nearby disused quarries which are notified on geological grounds.

The sand dune complex at Kenfig is also designated a Local Nature Reserve (LNR), with the same boundary as the SSSI, and there is also a second LNR at Frog Pond Wood to the north-east of the site.

6.3.2 Non-Statutory Sites

The area around Gaens Quarry is also rich in 'third-tier' sites, which are referred to locally as Sites of Importance for Nature Conservation (SINCs). These are sites which are considered to have nature conservation significance at the county or county borough level, but which are generally of less than national significance. They are not directly designated under a specific Act of Parliament, but are entities recognised within the broader context formed by the amended Town & Country Planning Act 1991 and its supporting framework of national planning guidance (eg Planning Policy Wales 2002; Planning Guidance (Wales): Technical Advice Note (Wales) No.5, 1996). SINCs are recognised by the local planning authority as being constrained for development, and are identified as such in the Unitary Development Plan (UDP) and its supporting national and local planning guidance documents. SINCs in Bridgend County Borough are listed in the *Bridgend County Borough Local Biodiversity Action Plan* (the 'LBAP' – BBP 2002).

Plan 1 of Appendix 6/1 shows only those SINCs which lie within about 2km of Gaens Quarry. The most significant of these is Site No. CYN-1-N ('Cornelly Quarry') which actually includes the existing Gaens Quarry envelope, together with the adjacent Pant Mawr Quarry. Lime Kiln Wood, an area of ancient woodland which is contiguous with the northern boundary of Gaens Quarry, is also designated as a SINC (No. CYN-5-S), as is Old Ballas Wood which lies immediately to the north-east (CYN-3-N). Other SINCs lie somewhat further away to the east and south of Gaens Quarry.

6.4 Survey Results: Habitats and Vegetation

The results of the vegetation and habitats survey are shown on Plan 2 of Appendix 6/1 of this report, and are described briefly below. Lists of the species recorded are given at Appendix 6/2.

6.4.1 Notable plant species

The surveys to date have recorded eight species which are regarded as regionally uncommon, and which feature as 'Contributory Species' in the *Guidelines for the Selection of Wildlife Sites in South Wales* (SWWSP 2004). These comprise wayfaring tree (*Viburnum lantana*), yellow-wort (*Blackstonia perfoliata*), greater knapweed (*Centaurea scabiosa*), woolly thistle (*Cirsium eriophorum*), viper's-bugloss (*Echium vulgare*), bee orchid (*Ophrys apifera*), common rock-rose (*Helianthemum nummularium*), and hawkweed oxtongue (*Picris hieracioides*).

In addition, seven species which are somewhat localised in the Glamorgan regional context have also been recorded on the site. These comprise kidney vetch (*Anthyllis vulneraria*), musk thistle (*Carduus nutans*), carline thistle (*Carlina vulgaris*), wild basil (*Clinopodium vulgare*), musk mallow (*Malva moschata*), common restharrow (*Ononis repens*) and field madder (*Sherardia arvensis*).

Bluebell (*Hyacinthoides non-scripta*) is also present on the site. This species, whilst not uncommon in Wales, is protected with respect to collection for trade under the amended Wildlife and Countryside Act 1981.

6.4.2 Woodland

Semi-natural woodland is of limited extent on the site, the main area being ***Woodland W1*** shown on Plan 2 of Appendix 6/10 which lies along the southern quarry rim. This area probably comprises a remnant of a much larger woodland which formerly extended along the steep limestone ridge which forms the quarry edge. The woodland is now reduced to a thin strip running along much of the south-western Gaens Quarry boundary, but is locally more extensive where it extends off-site to the south into the adjacent Pant Mawr Quarry. It has evidently suffered from extensive disturbance as a result of the quarrying activities. Although retaining some of its calcareous vegetation, the woodland within the quarry envelope appears extensively degraded, and is generally very densely shaded.

Woodland W1 comprises mature woodland on uneven ground which is dominated by tall ash (*Fraxinus excelsior*) with sycamore (*Acer pseudoplatanus*) locally frequent, and occasional pedunculate oak (*Quercus robur*). There is a dense and largely impenetrable understorey of species such as common hawthorn (*Crataegus monogyna*), blackthorn (*Prunus spinosa*), wild roses (*Rosa* spp) and bramble (*Rubus fruticosus* agg), together with other shrubs such as grey willow (*Salix cinerea*), goat willow (*S. caprea*), dogwood (*Cornus sanguinea*) and wayfaring tree (*Viburnum lantana*). Common gorse (*Ulex europaeus*) is frequent near the woodland edges and in small clearings.

The ground layer is mostly very shaded, and comprises shade-tolerant species such as ivy (*Hedera helix*), bramble and ferns including male fern (*Dryopteris felix-mas*), hart's-tongue (*Phyllitis scolopendrium*) and common polypody (*Polypodium vulgare*). Other typical woodland ground flora species include frequent wood false-brome (*Brachypodium sylvaticum*), wood avens (*Geum urbanum*) and herb robert (*Geranium robertianum*), and less-frequent bluebell (*Hyacinthoides non-scripta*), cowslip (*Primula veris*), enchanter's-nightshade (*Circaea lutetiana*), cuckoopint (*Arum maculatum*) and wild strawberry (*Fragaria vesca*). Bracken (*Pteridium aquilinum*) is locally frequent in small clearings and at the woodland edges. Climbing species include large bindweed (*Calystegia sylvatica*), black bryony (*Tamus communis*), honeysuckle (*Lonicera periclymenum*) and, rarely, hop (*Humulus lupulus*).

The northern edge of Gaens Quarry lies against ***Lime Kiln Wood***, the bulk of which lies off-site to the north of the quarry. This comprises ancient semi-natural woodland dominated by ash, with sycamore and oak. The woodland appears to be more species-diverse than Woodland W1, the understorey containing additional species such as hazel (*Corylus avellana*), field maple (*Acer campestre*) and holly (*Ilex aquifolium*). The ground flora is extensively dominated by dog's-mercury (*Mercurialis perennis*), with bluebell, enchanter's-nightshade and ferns.

A small sliver of the southern edge of Lime Kiln Wood has been severed by the existing access road around the northern quarry rim, and now lies on the upper slope of the active quarry face. Further east there has been stripping of topsoils and excavation right up to the southern edge of the woodland.

6.4.3 Scrub Habitats

Scrub is scattered across the upper faces and benches of the main quarry where these have not been worked recently, and elsewhere on old spoil mounds etc. Buddleia (*Buddleja davidii*) is the main species, but there are also occasional shrubs of other species such as elder (*Sambucus nigra*), ash and hawthorn. Red valerian (*Centranthus ruber*), a low-growing woody shrub, is also frequent or abundant in such situations.

There is an area of dense scrub to the south-eastern rim of the quarry, where a linear strip of scrub extends from the eastern end of Woodland W1. The scrub canopy extends around the lower flanks and side-slopes of the mounded area in the quarry's south-eastern corner, and is developed on broken ground, thin soils and old spoil heaps. The scrub in this area is moderately dense and comprises chiefly grey willow, together with goat willow, ash, sycamore, hazel, wild rose, hawthorn and gorse. There is typically a somewhat skeletal ground flora beneath the scrub canopy, comprising species such as wood false-brome, ivy, wild strawberry and occasional foxglove (*Digitalis purpurea*). Honeysuckle and traveller's-joy (*Clematis vitalba*) are locally frequent as climbers. Bracken is locally abundant. *Cotoneaster horizontalis* also occurs.

6.4.4 Hedgerows

There is only one hedgerow in the study area. This is ***Hedge H1*** shown on Plan 2 of Appendix 6/10 which forms the easternmost boundary of the quarry envelope. The hedgerow is moderately tall and stands on a hedgebank with grassy sides. The canopy is mixed and contains hazel, hawthorn, field maple, elder, blackthorn, gorse, ash, sycamore and bramble. The bank beneath supports a shade-tolerant flora which includes cuckoopint, enchanter's-nightshade, wood false-brome, herb robert, bluebell, ground ivy (*Glechoma hederacea*), red campion (*Silene dioica*), wood avens, dog's-mercury, hart's-tongue fern and primrose (*Primula vulgaris*), amongst others.

This hedgerow had a HEGS score of 2-, indicating moderate to high nature conservation value. It was also assessed as meeting the landscape and wildlife criteria for qualification as an 'Important Hedgerow' as defined by the Hedgerows Regulations 1997.

6.4.5 Grasslands

Grasslands, as opposed to well-developed ephemeral and pioneer vegetation, are mainly confined to the quarry rim. Some very small areas of original swards appear to survive on thin but undisturbed soils around the quarry rim to the south, and these are chiefly of a calcareous nature. However, these grade almost imperceptibly into secondary swards which have developed on old spoil mounds and other disturbed areas (see 'Ephemeral/Short Perennial Communities', below).

The most extensive area of grassland within the study area is a section of semi-improved calcareous grassland on the eastern quarry rim (***Area G1***). This comprises grasses such as red fescue (*Festuca rubra*), common bent (*Agrostis capillaris*), crested dog's-tail (*Cynosurus cristatus*), creeping bent (*Agrostis stolonifera*), Yorkshire fog (*Holcus lanatus*), Timothy (*Phleum pratense*) and, rarely, quaking-grass (*Briza media*); glaucous sedge (*Carex flacca*) is frequent. There is a high percentage and good diversity of characteristic calcicole forbs (ie non-grass herbaceous species) including, salad burnet (*Sanguisorba minor*), cowslip, eyebright (*Euphrasia* sp), lady's-bedstraw (*Galium verum*), perforate St John's-wort (*Hypericum perforatum*), common rock-rose, greater knapweed (*Centaurea scabiosa*), agrimony (*Agrimonia eupatorum*), fairy flax (*Linum catharticum*), hop trefoil (*Trifolim campestre*) wild strawberry, musk mallow (*Malva moschata*), wood sage (*Teucrium scorodonia*), and kidney vetch (*Anthyllis vulneraria*). Bee orchids (*Ophrys apifera*) occur rarely. More widespread grassland species also occur, such as common knapweed (*Centaurea nigra*), bird's-foot trefoil (*Lotus corniculatus*), ox-eye daisy (*Leucanthemum vulgare*) and ribwort plantain (*Plantago lanceolata*); primrose is locally frequent. Where the sward is more open, grading into adjacent ephemeral/short perennial vegetation on disturbed soils, species such as yellow-wort (*Blackstonia perfoliata*), viper's-bugloss (*Echium vulgare*) and common centaury (*Centaurium erthyraea*) are frequent.

The soils of the northern parts of the quarry appear to be less calcareous in nature and the vegetation correspondingly more neutral. A small area of ***remnant verge*** is present on an old bank on the northern quarry boundary, supporting semi-improved neutral grassland beneath a scatter of trees and shrubs. This is dominated by false oat-grass (*Arrhenatherum elatius*), Yorkshire fog and creeping bent with forbs such as bird's-foot trefoil, creeping cinquefoil (*Potentilla reptans*), salad burnet, field bindweed (*Convolvulus arvensis*), zigzag clover (*Trifolium medium*), common nettle (*Urtica dioica*), spear thistle (*Cirsium vulgare*) dandelion (*Taraxacum officinalis* agg) and teasel (*Dipsacus fullonum*). Marsh woundwort (*Stachys palustris*) and field horsetail (*Equisetum arvensis*) occur locally on damper ground along the line of a remnant ditch at the foot of the bank.

There is also a small neutral patch towards the north-west of the site. Yorkshire fog is the dominant grass, with ox-eye daisy being the most frequent and abundant broadleaved forb. Other species include viper's bugloss, red valerian, docks and a small patch of gorse.

6.4.6 Ephemeral/Short Perennial Communities

These habitats are extensive throughout the quarry and are very varied, occurring initially as pioneer vegetation on newly-exposed and disturbed soils, and then developing typically as skeletal swards. Where there is sufficient depth of soil to allow it they may ultimately become established as either secondary grassland, ruderal vegetation or scrub habitats. These are usually of a calcareous nature, although they may also be variably of neutral character or mixtures of the two.

Newly-exposed and disturbed soils are typically invaded by species such as prickly ox-tongue (*Picris echioides*), viper's-bugloss, Yorkshire fog, mayweeds (*Matricaria recutita, Tripleurospermum inodorum*), sow-thistles (*Sonchus* spp), wild strawberry, common centaury, yellow-wort and scarlet pimpernel (*Anagalis arvensis*). On very bare ledges and faces, often it is only red valerian and buddleia which can establish a foothold.

A very wide range of species may be present in the more established stages, of which only the most characteristic and interesting are listed here. Common species include rough hawkbit (*Leontodon hispidus*), smooth hawk's-beard (*Crepis capillaris*), ox-eye daisy, ribwort plantain, wood false-brome, perforate St John's-wort (*Hypericum perforatum*), silverweed (*Potentilla anserina*), wood-sage, creeping bent, Yorkshire fog, dewberry (*Rubus caesius*), yarrow (*Achillea millefolium*), wild carrot (*Daucus carota*), melilot (*Melilotus* spp) and hedge-mustard (*Sisymbrium officinale*). More interesting species which typically occur less frequently include eyebright, field madder (*Sherardia arvensis*), fairy flax, musk mallow, wild basil, wild marjoram (*Origanum vulgare*), mouse-eared hawkweed (*Pilosella officinalis*), Canadian fleabane (*Conyza canadensis*), cowslip, primrose, carline thistle (*Carlina vulgaris*), woolly thistle (*Cirsium eriophorum*), common restharrow (*Ononis repens*), agrimony, lady's-bedstraw, bee orchid and vervain (*Verbena officinalis*). Common spotted-orchids (*Dactylorrhiza fuschii*) are locally frequent in the north-west of the site, especially around the old conveyor equipment, and also occur rarely elsewhere.

On deeper soils tall species may become established, often forming rather rank stands of ruderal ('wasteground') vegetation. These include common nettle, wild parsnip (*Pastinaca sativa*), hemp-agrimony (*Eupatorium cannabium*), thistles (*Cirsium* spp), docks (*Rumex* spp), rosebay willowherb (*Chamerion angustifolium*) and bramble. Scrub may also develop amongst such stands.

On damp ground, rushes (*Juncus* spp) are common, together with species such as field horsetail water mint (*Mentha aquatica*), redshank (*Persicaria maculata*) and fleabane (*Pulicaria dysenterica*). Purple moor-grass (*Molinia caerulea*) and tufted hair-grass (*Deschampsia cespitosa*) may also occur very rarely in such situations.

6.4.7 Lagoons

At the time of survey two lagoons were present within the study area, though lagoons tend to be a transitory feature of quarries. They are usually excavated as 'sumps' to contain drainage water from the quarry but are often subsequently 'quarried away', being replaced by a new sump at a different location in the quarry. Hence lagoons in active quarry use are seldom of any great conservation significance.

In 2013, the lagoons at Gaens Quarry were set in deep hollows excavated in the rock, and had steep banks and a bare rock substrate. There is a small amount of floating sweet-grass (*Glyceria fluitans*) present in the larger lagoon.

6.4.8 Temporary Pool

There is a temporary pool along the woodland ride at the northern boundary of the quarry. The pool is shallow and contains rushes (*Juncus inflexus*, *J. effusus* and *J. articulatus*) and sedges (*Carex otrubae, C. flacca* and *C.ovalis*) around its edges.

6.4.9 Main Quarry Working Area

The main working area of the quarry is subject to high levels of disturbance and disruption. Very little vegetation persists in this area, except for some scattered areas of ephemeral/short perennial vegetation on some of the highest ledges and slopes, mainly to the south and south-east. Skeletal pioneer elements of this vegetation (mainly red valerian and buddleia) are developing elsewhere on older faces and spoil heaps, but none of these are more than about 12 months or so in age and most are in a state of recent disturbance. Most of the main working area therefore comprises bare rock and recent spoil. Some of the working areas could not be accessed for health and safety reasons, but were examined at a distance using binoculars.

6.4.10 Buildings

There are several industrial buildings in the north-west of the site, which are actively used by the quarry. These include a range of structures, including buildings composed of pre-fabricated metal sheeting and brick buildings with concrete roofs. These buildings were not inspected in detail as they are not likely to be affected by the proposed works.

6.4.11 Historic Records

Data was obtained from the Phase 1 habitat survey of the county which was undertaken by the former Nature Conservancy Council (NCC) during the period 1992-96. During this previous survey, much of the site was classified as comprising acidic/neutral scree.

6.5 Survey Results:Fauna

6.5.1 Bats

All species of bats and their roosting sites are protected under the EU Directive on the Conservation of Natural Habitats and of Wild Flora and Fauna (92/43/EEC; the ‘Habitats Directive’), implemented in the UK via the Conservation (Natural Habitats &c.) Regulations 1994 (the ‘Habitats Regulations’) as amended in 2007, being designated as ‘European Protected Species’ by the latter. The roosting places used by bats are also protected against unauthorised disturbance or obstruction under the amended Wildlife & Countryside Act 1981. Several bats are listed as ‘Priority Species’ for conservation in the UK Biodiversity Action Plan (UK BAP: UKSG 1995; UKBG 1998-99; BRIG 2007) and its Welsh equivalent (WAG 2003; WBP 2007), and bats are also subject to a general ‘Species Action Plan’ (SAP) in the Bridgend Local Biodiversity Action Plan (LBAP: BBP 2002).

A SEWBReC data search revealed no records of bats on or within 1km of the site, although this is likely due to a lack of recording.

A flight survey of the site carried out in 2003 records common pipistrelle (*Pipistrellus pipistrellus*) at several locations around the quarry rim, particularly along the edges of Woodland W1 and Lime Kiln Wood, and flying along the eastern boundary hedge. Pipistrelles were also recorded foraging in the southern mounded areas. A myotid bat (*Myotis* sp) was recorded briefly near the edge of Lime Kiln Wood.

The flight surveys carried out in 2008 yielded moderate numbers of bats. Common pipistrelle (*Pipistrellus pipistrellus*) and soprano pipistrelle (*P. pygmaeus*) bats were recorded foraging at several locations around the quarry rim, particularly along the edges of Woodland W1 and Lime Kiln Wood, and flying along the eastern boundary hedge. No evidence of autumn swarming was recorded in 2008.

The 2013 surveys yielded a very good range of species, the majority of which were recorded around the woodlands on the edges of the quarry, however, and not within the quarry itself; see Plan 3 of Appendix 6/10 for locations of these encounters.

The most notable species recorded in 2013 was barbastelle (*Barbastella barbastellus*), a scarce and uncommon bat. This species was recorded on one occasion approximately 150m beyond the eastern boundary of the quarry near to Lime Kiln Wood. It is quite possible that this species roosts in the wooded habitats in the area; it is unlikely to be roosting within the quarry itself. Lesser horseshoe bat (*Rhinolophus hipposideros*), another relatively scarce species, was recorded foraging just beyond the southern boundary of the site. This species tends to roost in buildings with large, warm open spaces (attics, open barns, boiler rooms, etc) as well as caves, particularly during hibernation.

The other species recorded were noctule (*Nyctalus noctula*) common pipistrelle, soprano pipistrelle, brown long-eared (*Plecotus auritus*) and an unidentified myotid (*Myotis* sp.), possibly Brandt's (*M. brandti*). Only common pipistrelle was recorded within the boundary of the quarry itself, the remainder were recorded foraging around the edges, beyond the site boundary.

No roosting was recorded during the surveys, though it is possible that bats roost within the quarry area, possibly utilising crevices and hollows in the quarry faces, although the great majority of these are in too disturbed a condition to be suitable for this purpose (the quarry is still in use and there is frequent blasting at the base of the quarry cliffs). It is considered far more likely that bats occur in summer roosts in the larger trees and amongst rocky exposures etc in the peripheral habitats, especially Woodland W1 and along the southern edge of the quarry. However, no evidence is currently available to support this.

6.5.2 Dormouse

Dormouse is also a 'European Protected Species' afforded full statutory protection under European and UK legislation which extends to the habitats which support it, and therefore of similar legal status to bats (see above). It is also a Priority Species of the UK BAP and its Welsh equivalent, and is subject to a SAP in the Bridgend LBAP.

There are no previous records of dormouse within the study area, which does not lie adjacent to any known populations; the SEWBReC search did not reveal any records of dormouse within 1km of the site (SEWBReC data, 2013).

Searches were made in 2003, 2008 and 2013 for hazelnuts showing the characteristic signs of having been gnawed by dormouse in suitable habitats for this species. Of the hazelnuts which were found, none had the characteristic feeding signs of dormouse. A few hazelnuts were found uneaten, and some were found to have been handled either by other small mammals such as grey squirrel and wood mouse, or by birds such as woodpeckers.

Despite the above, assessment of the hedgerow, woodlands and scrub habitats around the periphery of the study area indicate that they have some characteristics which could make them potentially suitable for dormouse, for example in containing moderate abundances of hazel, hawthorn and bramble, and some honeysuckle, all of which are key food sources for this species. The hedgerow is moderately tall and dense, with a bushy canopy, which are also positive features for this species, although connectivity with other habitats is low. However, it is likely that the site is too isolated from nearby populations and suffers too high a level of disturbance to be optimal for dormouse and the presence of this species is therefore considered unlikely. Probably the best opportunities for this species would be off-site in Lime Kiln Wood.

6.5.3 Badger

Badgers are fully protected in the UK under the terms of the Protection of Badgers Act 1992. Protection applies both to the animal itself and to its nesting burrows (setts). Current interpretation of the Act also confers a degree of protection to areas which are of key significance to foraging badgers. Badgers remain comparatively widespread and common throughout the UK and in Wales, and are increasing in numbers in many areas although they remain rare and localised in some. Whilst not rare nationally, the species is nevertheless listed as a 'Species of Conservation Concern' in the UK BAP.

There are records of badger (including setts) within 1km of the study area (SEWBReC data and Glamorgan Badger Group *pers comm*). There are at least four known badger setts in the surrounding area, including a large breeding sett. The 2003 survey found possible evidence of badgers (trails and runs) in and around Woodland W1, but no setts of this species were found within the quarry area. The 2008 survey found no evidence of badger, however in the 2013 surveys, prints of an adult badger and cubs were recorded just beyond the northern boundary of the site on a mud track behind the main office/car park area (see Plan 6 of Appendix 6/1 for location).

The possibility of setts in the inaccessible parts of Woodland W1 could not be ruled out, but there was no evidence to suggest this. It is more likely that badger occasionally forages around the rim of the quarry, or commutes through the peripheral areas *en route* between setts and to other foraging grounds.

6.5.4 Other mammals

The presence of other specially protected mammals, such as water vole and otter, was assessed as unlikely due to the lack of suitable habitat for such species.

Rabbits were frequent around the quarry rim and a fox was recorded off-site in the field to the east of the quarry. The presence of wood mouse was inferred from feeding remains, and vole burrows were recorded beneath reptile refugia in 2013; the 2003 survey also found a dead pygmy shrew beneath scrub on the southern boundary of the site. It is likely that a range of other mammals (eg mice, hedgehog, etc) occur in peripheral features such as the hedgerow, woodlands, scrub and grasslands, either as residents or as occasional visitors, but it is considered unlikely that there is any extensive use of the main working area of the quarry due to disturbance and noise etc.

6.5.5 Birds

Nearly all species of bird are protected against killing or injury as individuals under the emended Wildlife & Countryside Act 1981, and this protection extends to their nests, eggs and young. A number of especially rare species are subject to enhanced protection under UK law against disturbance whilst nesting by virtue of their listing on Schedule 1 of the Act, and a range of rare species are subject to special conservation requirements under the EU Directive on the Conservation of Wild Birds 1979 ('the Birds Directive').

The SEWBReC data trawl revealed a number of interesting records in the vicinity of the site, but no records from the site itself. Records within 1km include species of conservation significance that are listed on Schedule 1 of the Wildlife and Countryside Act; these comprise barn owl, red kite, goshawk and peregrine falcon. The latter species, a typical quarry-cliff nesting bird, has been recorded breeding in the Cornelly Quarry Complex itself in 2004-2005, but not from Gaens Quarry.

The survey results are described briefly below and the results from 2013 are shown on Plan 4 of Appendix 6/10. All of the species recorded in 2013 are listed in Appendix 6/1 which also sets out the statutory and conservation designations which apply in each case.

2003 surveys

Species of interest recorded in the vicinity of the site in 2003 included bullfinch (Priority Species in UK BAP), linnet (Priority Species in UK BAP and RSPB Red List of Species of Conservation Concern) and song thrush; all three species are UK BAP listed, while linnet and song thrush are also on RSPB's Red List of Species of Conservation Concern. All three were considered likely to be breeding on- or in the vicinity of the site, especially in the scrub and woodland habitats.

In addition, peregrine was recorded within the quarry in 2003 but was not believed to be nesting in Gaens Quarry itself. Kestrel was also recorded foraging over the site; kestrel is listed on Section 42 List of Species of Principal Importance in Wales (WBP 2007). A moderate range of wintering bird species was recorded, including kestrel and meadow pipit.

2008 surveys

The site was found to support a moderate diversity of bird fauna in 2008, totalling some 35 species, with at least 23 species showing evidence of breeding or being suspected of breeding. The remainder were considered likely to use the site mainly for wintering, roosting and/or feeding. The nesting birds were chiefly associated with the woodland, scrub, grasslands and transitional habitats of the southern quarry rim, but were also associated with Lime Kiln Wood, the hedgerow and other peripheral habitats.

Peregrine was again recorded flying within the site in 2008, but it was not believed to be nesting in Gaens Quarry. Kestrel was also recorded flying over the site.

Seven of the species recorded, comprising bullfinch, dunnock, herring gull, linnet, house sparrow, starling and song thrush, are listed as ‘Priority Species’ in the UK BAP and its Welsh equivalent; kestrel was also recorded. Only bullfinch, dunnock, house sparrow and song thrush showed evidence of breeding in 2008, however.

2013 surveys

A total of 21 bird species were recorded in 2013, with at least 13 showing evidence of breeding or being suspected of breeding. As in previous surveys, these were mainly associated with the woodland, scrub, grasslands and transitional habitats as outlined in Plan 4 of Appendix 6/10. Species of interest included dunnock, starling and linnet, all of which are listed on the UK BAP and its Welsh equivalent. Starling and linnet are also on RSPB’s Red List of Species of Conservation Concern. Only dunnock and starling showed evidence of breeding during the current surveys, though it is likely that linnet breed nearby.

Barn owl, a Schedule 1 species, was heard in the distance towards the north of the site during one of the bat surveys. No evidence of barn owl was recorded on the site itself and this species is not considered to be nesting on the site.

Many of the cliff faces of the quarry are evidently used as nesting areas by good numbers of jackdaw. There was also evidence of raven, a locally common species, showing breeding behaviour on the northern edge of the site and it is possible that it nests on the cliff faces.

Peregrine was not recorded in the 2013 surveys and is not considered to use Gaens Quarry for breeding, though it is likely to use the site for foraging purposes.

6.5.6 Reptiles

Four native reptile species occur in Glamorgan, comprising common lizard, slow-worm, adder and grass snake. These are all afforded so-called ‘partial protection’ under the amended Wildlife & Countryside Act 1981, which prohibits the killing or injury of individuals. However, there is no direct protection extended to the habitats which support these species. Whilst not rare nationally, these species are all declining in range and population size throughout the UK, and are listed as Priority Species in the UK BAP and its Welsh equivalent.

The SEWBReC data trawl did not reveal any reptile records within 1km of the site. This is likely to be due to a lack of recording in the area.

Both common lizard and slow-worm were recorded in the 2008 survey, occupying the undisturbed habitats around the northern and eastern habitats of the quarry edge.

The results of the 2013 survey are outlined below. Both common lizard and slow-worm were again recorded on the site, primarily in areas of scrub/transitional grassland. Adder may also occur in some peripheral areas, but were not recorded during any of the surveys; both adder and grass snake are considered less likely to occur with any frequency in the study area.

Table 6-1 Reptile Refugia Survey Results

Check Date	Reptiles Recorded (Area found)	Other Species Recorded (Area found)	Weather Conditions
25 Jun 2013	Slow-worm male (C)		Dry, still, sunny
3 Jul 2013	Slow-worm adult (A, C, E) Slow-worm juvenile (A) Common lizard adult (E)	Common frog (D)	Dry, still, sunny
4 Jul 2013	Slow-worm adult (A, C, E)		Dry, still, sunny
10 Jul 2013	Slow-worm male (B, C)	Common toad (A)	Dry, still, sunny
7 Aug 2013	Common lizard juvenile (A) Common lizard adult (D)	Common toad (A) Vole burrow (E)	Dry, still, sunny
21 Aug 2013	Common lizard adult x 3 (E)	Common toad (B)	Dry, still, sunny

N.B. The locations A, B, C, D and E correspond to those on Plan 5 of Appendix 6/10

6.5.7 Amphibians

Five native amphibian species occur in South Wales, comprising common frog, common toad, smooth newt, palmate newt and great crested newt. The latter species is nationally rare and declining, and is a 'European Protected Species' afforded full protection under both UK and European legislation (see under Bats, above). This protection also extends to the habitats which support the species. The other four species are not afforded any direct statutory protection, other than with respect to trade. Common toad and great crested newt are listed as Priority Species in the UK BAP and its Welsh equivalent.

There are records of breeding great crested newt populations approximately 1.5km to the south-west of the site, but no records from the site itself.

Bottle-trapping and lamping in 2003 yielded records of palmate newt, which was abundant in one of the quarry lagoons which was present at the time. In 2008, only two of the lagoons were deemed safe enough to survey using bottle-traps, but all three lagoons were surveyed by means of lamping. Palmate newt was recorded in all of the quarry lagoons in 2008, and common toad tadpoles were recorded in one of the lagoons.

Only lamping was carried out in 2013. This was undertaken on both lagoons and the temporary pool at the north of the site; see Plan 5 of Appendix 6/10 for locations. Palmate newt was recorded in low numbers in Lagoon A and the temporary pool. Common frog tadpoles were recorded in Lagoon A in July 2013 and an adult was found under a refugium on the trackway at the north-eastern end of the quarry (reptile refugia group D). Common toad adults were found under reptile refugia at several locations (see Plan 6 of Appendix 6/10). No amphibians were recorded in Lagoon B.

There are several other lagoons on adjacent quarries with 1km to the east of the site, including the Pant-Mawr Quarry lagoon which is within 50m of the eastern boundary of Gaens Quarry.

While these were not assessed in detail in the current study, they are assumed to be of similar character to that at Gaens Quarry. Pant-Mawr and Cornelly Quarry lagoons were fully surveyed for amphibians by David Clements Ecology in 2008, while Grove Quarry lagoon was surveyed in 2009; there was no evidence of great crested newt in these studies.

Great crested newt, a fully protected species, has not been recorded in any waterbodies or elsewhere on the quarry to date. Although this species can occur in quarry habitats, the lagoons are probably unsuitable for a breeding population as there is a distinct lack of vegetation for egg-laying, probably due to the transient nature of the lagoons as the quarry is still actively worked. It is considered very unlikely that this species is present in the study area.

6.5.8 Invertebrates

Upwards of 30,000 species of invertebrates are recorded in Britain, occurring in every available habitat. About 40 species are afforded full statutory protection in the UK under either European or British legislation.

There are several records of the protected marsh fritillary butterfly (*Euphydryas aurinia*) occurring approximately 2km to the north-east (SEWBReC data); this species is protected under Schedule 5 of the Wildlife and Countryside Act (1981), as well as being listed on the EC Habitats and Species Directive and a Priority Species on the UK BAP and its Welsh equivalent. Gaens Quarry and the immediate surrounding habitats are considered to be unsuitable for this species, which tends to occur in marshy grassland in Wales, and its presence in the quarry is therefore extremely unlikely.

There are records of the dingy skipper (*Erynnis tages*) approximately 700-800m to the east in Cornelly and Pant-mawr Quarries (SEWBReC data). While not statutorily protected, this species is listed on the UK BAP and Welsh equivalent due to recent population declines.

The UK BAP and Welsh equivalent-listed grayling butterfly (*Hipparchia semele*) was recorded on the site in 2003 but was not recorded during the 2008 surveys. A moderate range of common and ubiquitous invertebrates was recorded from the study area in 2008 including the UK and Welsh BAP-listed wall brown butterfly (*Lasiommata megera*) in the Eastern Quarry Rim Grassland.

Notable species recorded in the 2013 surveys again included wall brown butterfly, on the northern quarry edge. Dingy skipper was also recorded in several areas on the site.

No protected invertebrate species are considered likely to occur in the study area, and none have been recorded either in the past or by the present survey. Nevertheless, the study area as a whole offers a wide range of habitats suited to invertebrates. Calcareous grassland species, including molluscs, are likely to be well served by the species-rich calcareous grassland. Whilst invertebrates were not sampled in detail, observations gathered during the surveys suggested that the peripheral grasslands, ephemeral/short perennial vegetation, scrub, woodland and more-established areas of open ground, scree and compacted spoil all supported good numbers and diversity of invertebrates.

6.6 Evaluation of the study area

Evaluation guidelines: The sites and features may be evaluated at a number of levels and in accordance with a range of differing guidelines and criteria. Probably the best known guidelines are those put forward by Ratcliffe (1977) in defining a national series of primary conservation sites. With some modification these guidelines are considered to represent a sound basis for evaluating most sites in the UK, and they have therefore formed the basis for consideration of the study area, together with some additional guidelines considered appropriate to sites of less than national significance. These are briefly defined in **Appendix 6/2**

Evaluation categories: There is currently no nationally accepted system for the categorising of sites or features of biodiversity significance below the level of national value, criteria for which are set out by the former Nature Conservancy Council (1989, as amended). However, guidance for the identification of non-statutory sites of county significance (ie SINCs) is available in this instance (SWWSP 2004).

Evaluation of the study area: For the purposes of this study the habitats and features of the site have been provisionally evaluated and graded in accordance with the categories set out in **Appendix 6/3**. On the basis of the available survey, the habitats and features of the study area are evaluated as follows:

- No sites of ***International*** or ***National Value*** have been identified in the study area.
- Lime Kiln Wood and the immediately adjacent scrub habitats have been identified as being of ***County Value.*** Most of this woodland lies off-site to the north.
- The southern and eastern quarry rim, comprising woodland, calcareous grassland, scrub, hedgerow and ephemeral/short perennial habitats have been collectively identified as being of ***District Value***. There are also species-rich patches of ephemeral/short perennial habitats and neutral grassland in the north-west portion of the quarry; these are also considered to have ***District Value***.
- The remaining ephemeral/short perennial and scrub habitats of the northern/western areas have been collectively identified as being of ***High Local Value***.
- The lagoons and ephemeral/short perennial and scattered scrub habitats in the south have been identified as being of ***Local Value***.
- The main working area of the quarry is considered to be of ***Negligible*** value for wildlife.

This evaluation is shown on Plan 7 of Appendix 6/10.

6.7 Environmental Effects & Mitigation Measures: Ecology

6.7.1 Introduction

This section sets out the results of an assessment of impacts on ecology, undertaken by David Clements Ecology Ltd. The assessment includes a consideration of both direct impacts arising from the development, and the potential for indirect impacts on features at a distance from the quarry. The assessment draws upon the baseline study above and is based upon the description of the quarry development scheme which is described in Section 3 of the ES.

The site has been assessed using the ‘matrix’ methodology in which ecological value and magnitude of impact are combined to determine different grades of significance (see below). In addition, the site has been assessed in accordance with the Chartered Institute of Ecology and Environmental Management (CIEEM) *Guidelines for Ecological Impact Assessment in the United Kingdom* (IEEM 2006) **Appendix 6/7**. The outcomes of both assessments are consistent with one another.

Identified sites and features of nature conservation value in the study area were each evaluated against the guidelines set out in **Appendix 6/2**, and graded in accordance with categories set out at **Appendix 6/3**. Sites and features were graded as being either of International, National, County, District, High Local or Local value.

Potential ecological impacts were identified with reference to a checklist of typical impacts, set out at **Appendix 6/4**. The potential *magnitude* of any adverse impacts (ie the physical effects in terms of the extent of habitat loss or damage, disturbance to species etc) was estimated primarily in terms of landtake, disturbance, severance or contamination, and subjectively assessed as being either Very High, High, Medium, Low or Negligible: these terms are defined at **Appendix 6/5**.

The *significance* of the identified impacts (ie the conservation importance of the identified losses, disturbances etc) was then assessed using the Impact Significance Matrix shown below. Impacts arising as a result of the proposed development were assessed both in the absence of mitigation ('Potential Impacts') and following recommended mitigation ('Residual Impacts'). It is assumed that reasonable mitigation will be implemented in the manner proposed (or so as to achieve an equivalent effect), and the overall assessment of impact is therefore based primarily on the residual impact following mitigation. Impact significance was determined in each case as being either Very Major, Major, Moderate, Slight or Negligible: these terms are defined at **Appendix 6/6**.

6.7.2 Impact assessment criteria

In assessing the impact of any proposed development it is necessary to distinguish between the *magnitude* of the impact (ie the physical effects of the impact in terms of the extent of habitat loss or damage, disturbance to species etc) and the *significance* of the impact (ie the conservation importance of these losses, disturbances etc). This distinction is usually expressed in terms of:

Impact significance = magnitude of impact x value of site/feature

The values of the features within the study area have been set out above, in accordance with defined categories. Impact *magnitudes* are defined in **Appendix 6/5** and run in a scale from Very High to Negligible. The *significance* of the predicted impacts has been determined using the matrix shown at Table 6-2 below.

Impacts have been considered primarily with respect to:

- Land-take or severance; extent of disturbance to rare and protected species and potential for pollution. Other impacts have also been taken into account where these are likely to be of particular relevance.

- Long term or permanent residual impacts remaining after construction, taking into account the effects of proposed mitigation.

Table 6-2 Impact Significance Matrix

IMPACT MAGNITUDE	SITE VALUE					
	International	National	County	District	High Local	Local
Very High	Very Major Significance	Very Major Significance	Major Significance	Moderate Significance	Slight-Moderate Significance	Slight Significance
High	Very Major Significance	Major Significance	Moderate Significance	Slight-Moderate Significance	Slight Significance	Slight Significance
Medium	Major Significance	Moderate Significance	Slight-Moderate Significance	Slight Significance	Slight Significance	Negligible Significance
Low	Moderate-Major Significance	Slight-Moderate Significance	Slight Significance	Slight Significance	Negligible Significance	Negligible Significance
Negligible	Negligible-Slight Significance	Negligible-Slight Significance	Negligible Significance	Negligible Significance	Negligible Significance	Negligible Significance

6.8 Assessment of Impacts and Mitigation

Impacts have been assessed both in the absence of mitigation ('Potential Impacts') and following recommended mitigation ('Residual Impacts'). It is proposed that appropriate mitigation will be implemented in the manner proposed (or so as to achieve an equivalent effect), and the overall assessment of impact is therefore based primarily on the Residual Impact following mitigation.

Benefits have also been identified where relevant and where these may arise as a direct result of, or ancillary to, the development proposals.

Impacts are considered likely to be permanent unless otherwise indicated.

6.8.1 Impacts to Feature of County Value

6.8.2 Lime Kiln Wood

Potential Impacts

Lime Kiln Wood could suffer some slight disturbance along its southern edge from factors such as noise, vibration and dust for the duration of the development, however the Drawing 3782/4 (Phase 4) shows that there would be no direct loss of habitat or severance. The adverse impacts are likely to be localised along the southern edge, and should be attenuated fairly rapidly by the existing tree cover. The magnitude of potential impact is therefore assessed as Negligible, which has **Negligible** conservation significance.

In accordance with IEEM's (now CIEEM) Guidelines for Ecological Assessment (2006), a **negative effect** on the woodland is **unlikely**. Therefore, a **significant negative impact** at the County level is unlikely (see Appendix 6/7).

Mitigation Measures

The edge of the woodland would be clearly demarcated by post-and-rail fencing, and the woodland would be off-limits to site personnel and vehicles. No lighting will be directed towards the woodland.

6.8.3 Impact Assessment

Impacts to Lime Kiln Wood would be of **Negligible** significance, and would be temporary and short to medium term (matrix assessment).

The development is **unlikely** to have a negative effect on the woodland, and is therefore **unlikely** to be **significant** at the County level (CIEEM assessment).

6.8.4 Impacts to Features of District Value

Southern and Eastern Quarry Rim, Woodland W1, Hedgerow H1 and ephemeral/short perennial/grassy patches in north-west

Potential Impacts

The proposed development boundary cuts into a large part of the ***Southern and Eastern Quarry Rim***, which contains a valuable mix of calcareous grassland, scrub and ephemeral habitats. The woodland W1 will remain after extraction, though the edge habitats (primarily ephemeral vegetation) will be removed where they lie within the ROMP boundary on **[Plan 2]**. The hedgerow H1 will remain. It is assumed the areas of District Value within the blue IDO boundary on **[Plan 2]** will be removed or altered as part of the ancillary operations.

Given that many of these habitats are to be removed, <u>the magnitude of potential impact to these habitats would therefore be Very High</u>, which would have **Moderate** conservation significance. There will be increased disturbance from factors such as noise, vibration, human disturbance and dust etc for the duration of the development in retained habitats such as woodland W1, but this is likely to be temporary.

According to the IEEM (2006) methodology, it is **certain** that the development would have a **negative effect** on the habitat. A **significant negative impact** at the District level is therefore considered **certain**.

Mitigation Measures

The areas of District Value within the IDO boundary on Plan 2 of Appendix 6/10 should be retained. This mainly comprises the botanically rich areas of ephemeral/short perennial vegetation.

Consideration will be given to recreate some of the ephemeral habitats and calcareous grassland elsewhere in the quarry, by leaving areas of spoil to be colonised naturally (this is clearly how some of the current habitats have developed). If left to develop, this could replace some of the habitats lost to the quarrying although these areas will need to be demarcated as 'wildlife areas' and left undisturbed.

Areas outside of those required by the development will be clearly demarcated by post-and-rail fencing and would be off-limits to site personnel and vehicles. Careful siting of haulage routes and storage areas etc could reduce incidental losses, especially from features such as Woodland W1 and any areas of ephemeral vegetation/calcareous grassland that will remain.

Care will be taken to ensure that incidental disturbance to the hedgerow is minimised. A buffer strip of at least 2m from the hedge centreline will be identified and suitably fenced to prevent incursion by site vehicles and personnel. Any gaps which form in the hedge will be closed by means of replacement plantings of suitable native broadleaved species of local provenance, which will be tended in accordance with current standards for tree care.

Impact Assessment

As many of these habitats are being removed, the magnitude of residual impacts would probably <u>remain Very High</u>, and would be of **Moderate** conservation significance in the short-term. Impacts to areas within the quarrying boundary (mainly ephemeral/short perennial and grassland communities) would be permanent, although the disturbance impacts to retained habitats would be temporary and short to medium term. If the lost calcareous habitats are recreated elsewhere on site (in a designated area), and the areas within the IDO area are retained then the magnitude <u>could be decreased to Medium in the long-term</u> and therefore the significance could be reduced to **Slight.**

According to the IEEM methodology:

If the areas of District Value in the north-west (IDO Boundary area) are not retained and no habitats are recreated then impacts to areas within the extraction boundary would **certainly** have a **significant negative impact** at the District level. Disturbance impacts to areas outside of the boundary would probably be not significant at the District level in the long term.

If the areas of District Value in the north-west (IDO Boundary area) are retained and the ephemeral/calcareous habitats are recreated then impacts to areas within the extraction boundary would **certainly** have a **significant negative impact** at the District level in the short term, however it would be **unlikely** to have a **significant negative impact** in the long-term.

6.8.5 Impacts to Features of High Local Value

Potential Impacts

The ***Northern Quarry Rim***, which comprises a mosaic of ephemeral/short perennial vegetation and scrub would probably suffer at least some loss of habitats from the downslope edge, and the remainder would be subject to disturbance factors such as noise, vibration, human disturbance and dust etc, for the duration of the development; however, the majority of the habitats in this area would lie outside of the development boundary, and would suffer comparatively little direct or indirect impact. Despite the above, it is assumed that all of the areas of ephemeral/short perennial vegetation and grassy verges within the IDO boundary will be removed as part of the ancillary operations. Therefore, overall the magnitude of potential impact is therefore assessed as potentially being Very High, which has **Slight-Moderate** conservation significance.

According to the IEEM (2006) methodology, if the majority of habitats are lost in the IDO boundary area, then it is **certain** to have a **significant negative effect**.

Mitigation Measures

The areas of High Local Value within the IDO boundary should be retained as much as is possible. This mainly comprises the areas of ephemeral/short perennial vegetation and grassy verges around the track edges and buildings.

To compensate for the loss of habitats on the Northern Quarry Rim, the proposed restoration scheme proposes to recreate some of the ephemeral habitats and calcareous grassland elsewhere in the quarry, by leaving areas of spoil to be colonised naturally (this is clearly how some of the current habitats have developed). If left to develop, this could replace some of the habitats lost to the quarrying although these areas would need to be demarcated as 'wildlife areas' and left undisturbed.

Areas outside of those required by the development will be clearly demarcated by post-and-rail fencing and would be off-limits to site personnel and vehicles. Careful siting of haulage routes and storage areas etc could reduce incidental losses.

Impact Assessment

If none of the habitats within the IDO area can be retained, then the overall magnitude will remain Very High in the short-term, which will have a **slight-moderate** conservation significance. If the majority of these areas can be retained, then the magnitude would be Medium (as parts of the Northern Quarry Rim are still being removed) and the conservation significance could be reduced to **Slight** in the short-term. Furthermore, if habitat loss [of the Northern Quarry Rim] is compensated for by recreating some ephemeral habitats elsewhere on the site (see above), then the long-term magnitude is likely to be Low, which would have **Negligible** significance.

According to the IEEM methodology:

If the areas of High Local Value in the north-west (IDO Boundary area) are not retained and no habitats are recreated then impacts to areas within the extraction boundary would **certainly** have a **significant negative impact** at the High Local level. Disturbance impacts to areas outside of the boundary would probably be not significant at the High Local level in the long term.

If the areas of High Local Value in the north-west (IDO Boundary area) are retained and the ephemeral/calcareous habitats are recreated (to compensate for the loss of habitats in the Northern Quarry Rim), then impacts to areas within the extraction boundary would be **extremely unlikely** to have a **significant negative impact** in the long-term.

6.8.6 Impacts to Features of Local Value

Potential Impacts

The ***Lagoons*** would be lost to the development, but these are temporary features in any event and would be replaced by sumps of a similar type elsewhere in the quarry as the development progresses. The area of ephemeral/short perennial vegetation and scrub to the south of the site is not particularly species rich and is very patchy and transient. The magnitude of impact would be Very High, which would have **Slight** conservation significance, but this would attenuate rapidly to **Negligible** in the long term.

According to the IEEM methodology, a **significant negative impact** on these habitats in the short-term is **certain**. Therefore, **significant negative impact** at the Local level is **certain**. This will **probably** ameliorate to **not significant** in the long-term.

Mitigation Measures

In the long term there will be scope for the re-creation of habitats similar to those lost as part of the post-development landscaping.

Impact Assessment

Residual impacts to these features arising from the development would be of Slight to Negligible, temporary significance, ameliorating to Negligible in the medium to long term (matrix assessment).

With compensation, the development is **extremely unlikely** to have a negative effect in the long term (IEEM assessment).

6.8.7 Impacts to Protected and Priority Species

Potential Impacts

Impacts to protected species could potentially include loss or disturbance to nesting birds and reptiles; there may also be some potential for disruption to foraging badgers and bat roosts, although there is no evidence to date that the latter exist within the quarry area. Barbastelle, a rare species of bat, was recorded off-site to the east and is potentially roosting in Lime Kiln Woods. As discussed previously, negative effects on this woodland are considered to be unlikely and it is therefore considered that there will be negligible impact on barbastelle as a result of the development. While the cracks and crevices on the quarry faces could potentially be used by other species of bats, they are probably too heavily disturbed by the active quarry to have any value for use as roosts.

No nationally or regionally rare species would be affected, though there would be loss of feeding habitat for UK BAP Priority Species such as linnet and dunnock. There are also likely to be losses incurred by populations of a number of local plant species and invertebrates (including dingy skipper, a UK BAP Priority Species) as a result of the development.

Most of the affected species are likely to be able to find alternative habitat elsewhere in the study area. However, the impact on reptiles (especially in the south-eastern corner) could be significant as there are evidently breeding populations of common lizard and slow-worm on site; it is a statutory requirement that mitigation measures are set in place for these species.

On current information the potential for such impacts is estimated to be of Moderate conservation significance.

According to the IEEM methodology:

There is **unlikely** to be a **significant negative impact** on bat roosts as a result of the development. In the short to medium term there would **probably** be some loss of foraging habitat, and bats would therefore be compelled to seek alternative areas elsewhere in the vicinity. However, there is noted to be a reasonable availability of similar habitats in areas immediately adjacent to the study area and the overall impact is therefore **unlikely** to be **significant**.

In the absence of mitigation, **significant negative impacts** on reptiles are **certain**, which would **probably** have a negative impact on the local population. In the short to medium term there would **certainly** be some loss of habitat for reptiles, though there is noted to be a reasonable availability of similar habitats in areas immediately adjacent to the study area; mitigation measures should focus on translocating reptiles to these habitats. In the absence of mitigation, loss of habitat would **certainly** have a **significant negative impact** on the local reptile population.

In the absence of mitigation, **significant negative impacts** on nesting birds are **probable**, which would **probably** have a negative impact on the local population. In the short to medium term, there would **certainly** be a loss of nesting and foraging habitat, which would therefore be compelled to seek alternative areas elsewhere in the vicinity. However, there is noted to be a reasonable availability of similar habitats in areas immediately adjacent to the study area and the overall impact is therefore **unlikely** to be **significant** in most cases.

Impacts could potentially disrupt foraging badgers, however a **negative effect** on conservation status is considered to be **unlikely**. Therefore, a **significant negative impact** at the local level is **unlikely**.

There will certainly be a loss of habitat for dingy skipper butterfly, however, there is noted to be a reasonable availability of similar habitats in areas immediately adjacent to the study area and the overall impact is therefore **unlikely** to be **significant**.

Mitigation Measures

These will comprise:

- Prior inspection of large trees and any large crevices in undisturbed areas of the quarry faces to check for possible bat presences immediately ahead of any tree-surgery or quarrying works, and implementation of a suitable protocol to ensure that any bats which are found are dealt with in accordance with current legislation and best practice.

- Trees generally will be treated in accordance with the guidance provided by the Bat Conservation Trust (BCT 1997, *Bats and Trees: A Guide to the Management of Trees*).

- A precautionary approach towards common reptiles will concentrate primarily on minimising the potential for causing the death and injury of individuals during site clearance. A full method statement with respect to reptiles should be prepared and agreed in advance with the Local Authority ecologist and NRW, prior to the commencement of clearance. Current NRW guidance with respect to reptiles is provided at Appendix 6/9. Likely reptile mitigation strategies for the site include a fence, trap and clear operation for some of the more grassy areas and species deterrence strategies for the more rocky habitats; destructive searching is also likely to be required.

- Clearance of trees and scrub will avoid the main bird nesting season (March to August inclusive), to minimise the risk of destruction or disturbance of nests, eggs and nestlings.

- Suitable written protocols will be issued to contractors so that in the event of the discovery of bats, nesting birds, badgers or common reptiles at any time during operations, compliance with statutory obligations is ensured. These will require immediate temporary cessation of works, allowing time for consultation with NRW, and safe relocation or other mitigation as required.

- As outlined previously, there may be scope for the re-creation of similar habitats that currently occur both as the development progresses and in the post-development landscaping.

Impact Assessment

Residual impacts following mitigation are considered likely to be of no more than **Slight** or **Negligible** Significance. The overall impact is **unlikely** to be **significant** in most cases due to the reasonable availability of similar habitats in areas immediately adjacent to the study area (IEEM assessment).

6.8.8 Operational Phase Impacts

Most operational impacts are likely to be temporary, but may be medium to long term. In addition to the impacts already identified under habitats and species (above) there could also be potential for:

- Soil or watercourse contamination by oil, petrol and diesel from vehicles, and leachates from compounds and storage areas etc.

- Temporary disturbance to fauna species such as birds and mammals through presence of site vehicles and personnel, site lighting during winter evening work etc.

- Temporary severance of vertebrate foraging habitats and trails of mammals.

Mitigation measures would include:

- All mature trees and hedges to be retained will be treated in accordance with BS 5837 (2012 *Trees in Relation to Design, Demolition and Construction – Recommendations*).

- Prior definition and location of haul routes, compounds and storage areas in non-sensitive locations and with suitable buffer zones where adjacent to sensitive habitats.

- Maintenance of contractors vehicles in line with current best practice to ensure no leakage of oil, petrol and diesel etc.

- Appropriate bunding and cut-off drainage of refuelling areas, materials storage areas and mixing compounds in accordance with current best practice.

- Maintenance of vehicle baffles etc to minimise noise, in accordance with current best practice.

Residual operational phase impacts are assessed as likely to be of Low magnitude and of **Negligible significance** (matrix assessment).

6.9 Remote and Cumulative Impacts

The present assessment has been primarily with respect to impacts within the boundary of the development area itself, and its immediate environs. However, previous consultations with Natural Resources Wales has indicated a potential for remote and/or cumulative impacts to other sites of biodiversity significance in the vicinity, most notably the Kenfig SAC, the two main components of which lie about 2.5km to the west (Kenfig Dunes) and 3km to the south-east (Merthyr Mawr) respectively (see [Plan 1]).

The Kenfig SAC is recommended for designation for the following Priority Interests:

1) Fixed dune with herbaceous vegetation ('grey dunes')

2) Atlantic salt meadows (*Glauco-Pucinellietalia maritimae*)

3) Dunes with *Salix repens* spp *argentea* (*Salicion arenariae*)

4) Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp

5) Humid dune slacks

6) Fen orchid (*Liparis loeselii*)

7) Petalwort (*Petalophyllum ralfsii*)

In assessing likely effects on the Kenfig SAC, this ES reference is made to Chapter 7 of this ES, and to the following key documents:

- Core Management Plan (including Conservation Objectives) for Cefn Cribwr Grasslands SAC (CCW, 6 March 2008) *
- Ecohydrological guidelines for wet dune habitats: Wet dunes Phase 2 (Environment Agency, 2010)

The conservation objectives for these features are as follows:

Table 6-3 Kenfig SAC conservation objectives

Feature No(s).	Description	Vision for favourable conservation status
1, 2	Humid dune slacks and. dunes with *Salix repens* ssp. *argentea* (*Salicion arenariae*)	i) Dunes with *Salix repens* and humid dune slacks will occur as part of the dune system, their location will be determined by natural processes and appropriate grazing management ii) A range of successional stages will be found in both features ii) Factors affecting the features will be under control
3	Fixed dunes with herbaceous vegetation (`grey dunes`)	i) Fixed dunes with herbaceous vegetation (grey dunes) will occur where older, shifting dunes become more stabilised and in early successional stages become colonised by lichens and other species indicative of the transition from less mobile habitat. ii) The habitat will encompass a range of successional stages throughout the area, determined by patterns of natural factors and grazing. iii) Grey dunes will comprise a significant part of the dune system but will increase and decrease in extent and location as natural processes determine the landscape of the dune systems iv) All factors are under management control
4	Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp	i) Submerged *Chara* beds (mainly *Chara aspera* and *C. virgata*) growing in relatively shallow water form the predominant submerged macrophyte vegetation throughout most of the lake. ii) *Chara* occur at more than 50% frequency along regular surveillance transects within the Western and Central arms. iii) Charophyte species and uncommon pondweeds such as *Potamogeton gramineus* and *P.* x *nitens* are present in other embayments and pools, including *Tolypella glomerata* in dune pools. iv) The lake is spring-fed so nutrient levels remain low. One of the main nutrients (phosphorus) reaches no more than 25 micrograms per litre in regular sampling areas. Nitrogen levels in the water are low (less than 1 milligram per litre) and declining or stable. v) The lake water is clear, but well vegetated with dense beds of submerged and marginal plants. A Secchi disc is visible on the lake bed in the deepest part of the lake (2.6m). vi) Water depth is relatively stable, fluctuating naturally with groundwater. vii) Reed, swamp and fringing bur-reed are restricted to shallow zones –

		covering not more than 10% of the site. viii) All factors affecting the achievement of these conditions are under control.
5	Atlantic salt meadows	i) The quality of the saltmarsh is within specified limits ii) There is no increase in erosion along the length of the transition from salt marsh to sand dune iii) The saltmarsh flora will continue to include the following scarce species; *Limonium* *binervosum*, and *Frankenia laevis* iv) Light grazing by rabbits and /or stock will continue to be tolerated within limits v) The damaging effects of pony riding will have been reduced or eliminated
6	Petalwort	Will continue to be found at its current locations in each of the two SSSI in the SAC, and i) The species will be found where conditions are suitable in sufficient numbers to form a viable and sustainable population ii) The population will vary from year to year depending on conditions, especially in drier years, but the long term population will remain steady and sustainable iii) Suitable dune slacks will have patches of bare ground that is being colonised by jelly lichens (*Collema* spp.) and *Barbula* mosses. iv) The factors affecting the feature are under control
7	Fen orchid	i) Sufficient suitable habitat is present to support the populations ii) The factors affecting the feature are under control

Of these features, fixed dunes and Atlantic salt meadows are not dependent upon groundwater and are not considered further. Petalwort and fen orchid are both species of dune slack habitats and would be adversely affected if the integrity of the dune slack habitats was adversely affected. They are therefore considered inter alia with their supporting habitats. The Core Management Plan (including conservation objectives) for Kenfig SAC indicates that the division between humid dunes and dunes with Salix repens ssp argentea is unclear and difficult to define, as the latter occurs in the drier areas of mature dune slacks as well as in hummocks found around dune slacks. The Core Management Plan therefore considers these features together, and this approach is mirrored in this assessment.

The planned quarrying operations are not predicted to have any material impact on water quality within the surrounding area (Section 7.6.4 of the ES) and this matter is not considered further in this document.

Similarly, the quarrying developments are not predicted to cause saline intrusion into the SAC (Section 7.6.4 of the ES) and this matter is not considered further here.

The Scoping Direction requires that the ES considers the possibility that the quarrying operations may intercept a highly permeable feature such as a fissure in the limestone at depth, leading to a relatively rapid drawdown of the water table.

This risk has been assessed in detail and is dealt with in Chapter 7 of the ES which concludes that the risk of interception is very low Furthermore, the results of the groundwater model (Appendix 7/4 of ES) demonstrate that it would take a number of years for the effects of intercepting such a feature to become manifest as a hydrological change at the dune sands and, due to the likely small size of any such change, a further number of years for this to become manifest in the ecology of the SAC.

However, due to the nature of fissure distribution in limestone aquifers, the certainty that such an event could not occur cannot be guaranteed to the degree required of the Habitats Regulations.

For the purpose of managing this very small residual risk, a Water Management Plan has been developed and is provided in Appendix 7/5 to the ES. The Water Management Plan will allow interception of such a feature and resultant effects on water levels to be identified before any changes had occurred in the hydrology of the SAC. There would therefore be time to implement appropriate mitigation measures within and around the quarry to prevent the spread of effects to the SAC. The implementation of the Management Plan removes any residual uncertainty over the likely effects of encountering a highly permeable feature at depth and can be made a condition of any consent for the proposed works. This is consistent with regulation 61 (6) of the Habitats Regulations. For this reason, this potential effect is not discussed further in this document.

The degree of connection between the Kenfig SAC and the limestone aquifers in which all of the Cornelly area quarries are located has been the focus of major investigations by the Quarry Operators over the last 12 years. These phased investigation and associated extensive monitoring, which have been carried out in close consultation with the relevant regulators, have shed important insights into the behaviour of these systems. This conceptual understanding has allowed the development of a calibrated groundwater model which has been used as a tool for determining the likely degree of effect of the proposed developments on the hydrology of the SAC (as set out in Section 7 of the ES).

The hydro-geological conditions at the Kenfig Dunes part of the SAC differ from those at the Merthyr Mawr part. As a result, each is discussed separately in relation to effects during the quarry operation (during the 15-year ROMP period and beyond until cessation of operations) and thereafter during recovery.

6.9.1 Kenfig Dunes

The groundwater system that supports the humid dune slacks is almost entirely driven by direct rainfall over the site with a very small amount of runoff/overflow from minor aquifers to the east. There is also some downwards leakage from the sand to the underlying glaciofluvial sand and gravel. Section 7.4.5 describes the hydro-geological relationship between the Kenfig dune system and the underlying glaciofluvial sands and gravels. It demonstrates that water levels in the underlying glaciofluvial deposits show a distinctly different behaviour to those in the dunes, indicating that the dunes are not well connected to the underlying groundwater system due to the presence of an intervening layer of estuarine clay which separates the dune sand system from the glaciofluvial deposits.

In turn, the glaciofluvial deposits are not well connected to the limestone aquifers worked by the quarries. However, although the linkage between the quarries and the Kenfig Dunes part of the SAC are indirect and weak, due to the high level of proof required by the Habitats Directive, it has been necessary to quantify this mechanism as set out in Section 7 which concluded that there was poor connectivity around the south of Kenfig Pool, but in closer connection to the north and north east.

However, the clay layer that largely separates the dune system from the underlying groundwater system is not completely impermeable, and some linkage therefore exists between the two. It therefore follows that any change in the groundwater system in the underlying geology could have an effect on the almost "perched" aquifer that supports the vegetation communities within the dune system.

6.9.2 Potential Effects of planned developments at Gaens Quarry

The Core Management Plan for Kenfig SAC (CCW, 2008) states that 95% of the slack habitat within the SAC is found at Kenfig, with the remainder being found at Merthyr Mawr.

Section 8 of Appendix 7/1 to the ES summarises the water balance at the Kenfig Dunes:

"The water balance for the Kenfig Dunes system shows that almost all of the flow in the dune sands is sourced from direct rainfall (2% from surface water inflow). This flow leaves the system by a mixture of groundwater flow and overland flow via the slacks with a very small component of downwards leakage into the underlying sands and gravels."

The groundwater regime of the underlying solid geology therefore plays only a very minor role in the functioning of the dune slack vegetation communities within the dune system.

The document *Ecohydrological guidelines for wet dune habitats: Wet dunes Phase 2* sets out, in Table 3.1, the water table conditions for defining humid dune slack habitats, derived from a wide ranging literature review and data gathered from a range of UK dune systems, including Kenfig and Merthyr Mawr. This can be interpreted as giving the range of water table conditions required to sustain the various types of dune slack habitats. For the purpose of this assessment, the summer maximum values are most relevant, as these represent the period when the water table is at its lowest and when any significant medium term further lowering arising from the quarry operations is likely to affect the groundwater dependent vegetation communities of the dune slacks.

Table 7-4 Summer maximum water table conditions for defining humid dune slack habitat types (from EA, 2010)

Dune slack	Summer maximum
Young dune slack	-50 to -100 cm
Rain-fed dune slack	-50 to -200 cm
Rain –fed flow-through dune slack	-50 to -200 cm
Boundary slack (semi-aquatic)	-50 to -100 cm
Moist dune slack	-100 to -200 cm

The negative values represent depth below ground level.

Water levels within the Kenfig Dunes have been extensively monitored since 1986, via a series of dipwells throughout the site. Table K.6 of Appendix 7/1 to the ES (sub-appendix K) provides annual minimum and rolling three-yearly average water depths within the dip wells between 1997 and 2010. The rolling three yearly average values are considered to be the most appropriate dataset to base this assessment upon, as they reduce the effects of unusual individual years. Table 6.5 shows the rolling average summer minima within the Kenfig dipwell array, together with the elevation of the top of the dipwell (equating broadly to ground level), and converts the recorded values to depth below the ground surface.

Table 7-5 Minimum groundwater levels in Kenfig dipwells 1997-2010

Dipwell	Rolling 3 Year minimum OD (m)			Pipe installation level OD (m)	Mean in relation to ground level*	Min in relation to ground level*
	Min	**Mean**	**Max**			
CC10	7.2	7.4	7.6	8.3	-90	-110
CC11	7.9	8	8.1	8.7	-70	-80
CC117	9.7	9.9	10.1	10.46	-56	-76
CC12	6	6.1	6.2	6.82	-72	-82
CC139	9.5	9.7	10	10.22	-52	-72
CC2	9.7	9.8	10	10.4	-60	-70
CC24E	9.9	10.1	10.2	10.96	-86	-106
CC3	9.8	9.9	10.1	10.87	-97	-107
CC3.2	8.9	9.1	9.4	9.83	-73	-93
CC3.2A	9.5	9.7	9.9	10.25	-55	-75
CC34	9.4	9.5	9.7	10.26	-76	-86
CC4	9.4	9.8	10.1	10.64	-84	-124
CC5	9.7	9.9	10.2	10.63	-73	-93
CC6	9	9.2	9.5	9.82	-62	-82
CC6.1	9.8	10	10.2	10.47	-47	-67
CC7	8.7	9	9.3	10.01	-101	-131
CC8	8.6	8.8	9.1	9.78	-98	-118
CC9	8.4	8.6	8.8	9.56	-96	-116
Average					**-75**	**-94**

(*Values in relation to ground level have been converted to cm)

The dipwell data therefore indicate that all five of the habitat subcategories identified in the Ecohydrological guidelines are likely to be present at Kenfig.

Section 7.6.2 of the ES describes the simulated results of modelling of the proposed operations at Gaens Quarry alone, which show that at the Kenfig part of the SAC, there would be a decrease in simulated five year mean water levels of not more than 5 mm relative to baseline (current levels) and maximum change in water levels during the entire run period of 6 mm.

A change in groundwater levels of this predicted magnitude would be insufficient to shift any of the dune slack habitats within the Kenfig dunes system from one of the sub-categories described in the Ecohydrological guidelines to another, or to affect the bethic Chara vegetation community of Kenfig Pool. On this basis, is concluded that there would be no effect on the dune slack habitats at Kenfig Dunes during the quarry operation, resulting in an impact of no significance.

6.9.3 Potential Effects of Quarry Recovery

On decommissioning of the quarry, dewatering will cease. This will result in temporary effects on the surrounding groundwater regime as natural levels are re-instated. Once stabilised, the additional storage represented by the re-filled quarry voids will have the positive effect of giving the local groundwater system additional tolerance to droughts (Section 7.8 of the ES).

The effects of this temporary recovery period have been carefully modelled and the results are set out in Chapter 7 of the ES. A very conservative scenario has been adopted in which dewatering of all three quarries at their maximum extent ceases instantaneously and simultaneously and no residual pumping is retained. As reported in Section 7.8 of this ES, modelled effects of the effects of recovery at Gaens Quarry are dominated by those of recovery at Cornelly Quarry, and it is the results of this combined recovery that is considered in this impact assessment.

Without mitigation, it is predicted that there would be a short term lowering of groundwater levels in the dunes to the west of Kenfig Pool of up to 12 cm relative to baseline, although only during drought conditions. Elsewhere, in the dunes to the north and north west of Kenfig Pool, the maximum change over the modelled period is 3.5 cm (again in the absence of mitigation). As is the case with the operational stage, these changes are not likely to result in the summer maximum water table conditions that support the various dune slack habitats falling outside the ranges set out in the Ecohydrological guidelines, or of changes occurring to the habitats of the benthic vegetation of Chara species in Kenfig Pool. In the light of this, and their temporary nature (the largest changes are only simulated to occur for a few years), changes to the vegetation communities within the slack habitats are not predicted to arise as a result of the quarrying recovery period, and thus there is no effect on the habitats resulting in an impact of no significance.

Notwithstanding this conclusion, it would be possible for the Competent Authority to impose a condition to the ROMP Schedule of Conditions that required residual pumping to take place after decommissioning. This option is described in section 7.8.2 of the ES, and would reduce the simulated short term effects on the water tables at Kenfig Dunes to a maximum of 8cm, while increasing the recovery period.

6.9.4 Merthyr Mawr

Section 6.5 of Appendix 7/1 to the ES describes the relationship between the sands at Merthyr Mawr and the underlying limestone. As at Kenfig Dunes, a clay layer separates the two, giving rise to two distinct hydrogeological units. Furthermore, the dunes at Methyr Mawr are split into two topographic levels to the north and south of a step in the underlying limestone: an area at lower elevations where dune slacks form; and a higher area of drier sands. The latter area is independent of the underlying hydrological system and is not considered further in this assessment.

There are three main inputs to the groundwater system in the sands: runoff from less permeable catchments to the north east, direct recharge and intermittent flow from the underlying Carboniferous Limestone that discharges at the Burrows Well spring.

The overflow from the Burrows Well spring into the dunes creates locally flooded dune slacks that behave in a markedly different way from the 'normal' humid dune slacks at Kenfig Dunes and elsewhere in Merthyr Mawr: the spring switches on and off fairly suddenly in response to rainfall leading to rapid inundation followed by equally rapid drying and substantial falls in water level. The dune slacks in this area are thus hydrologically distinct from those elsewhere in the SAC. Therefore, for the area of the SAC that is affected by overflow from Burrows Well, hydrological effects are assessed by consideration of the simulated change in flows at the spring.

To the east and west of Burrows Well, a limited range of primarily rain-fed dune slacks occur separately from those that are dependent upon groundwater arising from Burrows Well. In these areas, hydrological effects are assessed by direct simulation of changes in groundwater levels.

6.9.5 Potential Effects during Quarry Operation

Conditions at Merthyr Mawr differ from those at Kenfig, as parts of the humid dune habitats are entirely dependent upon flows from Burrows Well. Section 7.6.2 of Chapter 7 of this ES highlights this, and notes that, when Burrows Well stops flowing each year, water levels fall by at least 3m.

Elsewhere, to the east and west, the dunes (Blown Sands) are primarily fed by rain, with a lesser contribution from diffuse seepage.

In the Blown Sand Merthyr Mawr SAC there is a simulated decline in five year mean water levels of not more than 2 mm and a maximum decline during the full run period of 3 mm.

Modelled changes in flow rates at Burrows Well show that flows would reduce by up to 0.9%, but on average would change by just over 0.5% over the 42 year period.

Compared with an inter-annual variation in the order of metres (Figure 7.3 of the ES), this amount of variation is negligible and would have no effect on the dune slack habitats at Merthyr Mawr resulting in an impact of no significance.

Potential Effects of Quarry Recovery

In the absence of mitigation, groundwater levels within the Blown Dunes at Merthyr Mawr are predicted to decline initially by up to 10 cm relative to baseline, but to increase above baseline by just over 5cm by the end of the recovery period. This is as a result of the "natural" baseline condition of the water table at Merthyr Mawr being slightly higher than at present.

Similarly, in the absence of mitigation, there is predicted to be an initial decline in flow rates from Burows Well of 4%, while the during the final five years of the simulated recovery period, flows are predicted to be 6% above current baseline.

Change of this magnitude would be insufficient to lead to summer maximum water table conditions altering to a point where the dune slack habitats they support would be affected. Consequently, no effect is predicted on the habitats resulting in an impact of no significance

Cumulative impacts

Section 7.7.2 of the ES sets out the predicted changes to groundwater levels arising from the combined operation of Cornelly, Grove and Gaens quarries at Kenfig Dunes and Merthyr Mawr, as part of Kenfig Dunes SAC. At Kenfig, a lowering of the water table by 1cm relative to baseline is predicted, while at Merthyr Mawr, the water table would lower by 1.5cm. Against the natural background variation in five year means, these changes are extremely small and would not give rise to impacts on the dune slack vegetation communities of the SAC.

The simulated RECOVERY model described in Chapter 7 accounted for the recovery of all three quarries. The Cumulative impacts of recovery are therefore identical to those described above.

Consequently, the combined operation and recovery of the three quarries is not considered to result in a significant cumulative impact on the SAC

6.9.6 Cefn Cribwr Grasslands SAC

The Cefn Cribwr Grasslands SAC also lies in the vicinity, the nearest part of which lies about 2km away to the north-east. The Priority Interests at Cefn Cribwr are:

1) Marsh fritillary butterfly (Eurodryas aurinia)

2) Molinia meadows on calcareous, peaty or clayey-silt-laden soils

While both of these interests are also dependant, at least in part, on ground water levels, detailed hydro-geological studies, reported in Chapter 7.0 of the present ES and in Section 2.4.2 of Appendix 7/1 of this ES, have concluded that no parts of the Cefn Cribwr Grasslands SAC are dependent upon groundwater systems that could be affected by Gaens Quarry. In light of this, it is assessed that there would be no effect on this site of international nature conservation value, such that the quarry proposals are likely to have no significant effect upon this SAC.

In addition to these internationally significant interests there are some seven SSSIs in the immediate vicinity which are designated at least in part for features which are dependant on ground water levels to a greater or lesser extent. These comprise:

1) Kenfig Pool & Dunes

2) Merthyr Mawr Warren

3) Penycastell, Cefn Cribwr

4) Waun-fawr, Cefn Cribwr

5) Waun Cimla

6) Caeau CefnCribwr

7) Brynbach, Cefn Cribwr

These sites, some of which overlap in part with the SACs, are designated for a range of wetland interests (chiefly marshy grasslands with abundant Molinia caerulea) which are considered to be nationally significant.

No effect is predicted on the Cefn Cribwr SAC, of which the four SSSIs are a component part. The SSSI designates the same habitat and species as the SAC – marshy grassland and marsh fritillary butterfly. As such, it is similarly concluded that the quarry operations will have no significant effect on this site of national nature conservation value.

6.10 Summary

A summary of the impact assessment is set out below.

Table 6-4 Summary of Impact Assessment

SITE OR FEATURE VALUE	IMPACT SIGNIFICANCE		ENHANCEMENTS/ BENEFITS
	Potential	Residual	
County Value areas (Lime Kiln Wood)	Negligible	Negligible	
District Value areas (S and E Quarry Rim, Woodland W1, Hedgerow H1 and ephemeral patches in IDO area)	Moderate	Moderate in short term Slight in long term if compensation habitats created	Potential to create wildlife areas
High Local Value areas (N Quarry Rim and ephemeral patches in IDO area)	Slight-Moderate	Slight-Moderate short term Negligible in long term if compensation habitats created	Potential to create wildlife areas
Local Value areas (Lagoons and ephemeral/scrub areas in south of quarry)	Slight-Negligible	Slight-Negligible	
Impacts to Species	Moderate	Negligible to Slight	
Construction Impacts	Slight	Negligible	

6.11 Planning Conditions

The proposed Conditions in respect of the continuation of extraction include the mitigation measures set out above, to include:

- Prior inspection of large trees and any large crevices in undisturbed areas of the quarry faces to check for possible bat presences immediately ahead of any tree-surgery or quarrying works, and implementation of a suitable protocol to ensure that any bats which are found are dealt with in accordance with current legislation and best practice.

- Trees generally will be treated in accordance with the guidance provided by the Bat Conservation Trust (BCT 1997, *Bats and Trees: A Guide to the Management of Trees*).

- A precautionary approach towards common reptiles will concentrate primarily on minimising the potential for causing the death and injury of individuals during site clearance. A full method statement with respect to reptiles should be prepared and agreed in advance with the Local Authority ecologist and NRW, prior to the commencement of clearance. Current NRW guidance with respect to reptiles is provided at Appendix 6/9. Likely reptile mitigation strategies for the site include a fence, trap and clear operation for some of the more grassy areas and species deterrence strategies for the more rocky habitats; destructive searching is also likely to be required.

- Clearance of trees and scrub will avoid the main bird nesting season (March to August inclusive), to minimise the risk of destruction or disturbance of nests, eggs and nestlings.

- Suitable written protocols will be issued to contractors so that in the event of the discovery of bats, nesting birds, badgers or common reptiles at any time during operations, compliance with statutory obligations is ensured. These will require immediate temporary cessation of works, allowing time for consultation with NRW, and safe relocation or other mitigation as required.

- As outlined previously, there may be scope for the re-creation of similar habitats that currently occur both as the development progresses and in the post-development landscaping.

7.0 HYDROLOGY AND HYDROGEOLOGY

7.1 Introduction

The potential relationship between the limestone quarries in the Cornelly area and the Kenfig/Cynffig SAC/SSSIs has been recognised since at least 1998 and was a significant driver for the 'calling in' of the initial ROMP applications at Gaens, Grove and Cornelly Quarries. A range of other potential impacts on the local water environment was also recognised at that time.

The proximity of the quarries is such that a joint assessment was commissioned by T. S. Rees Limited (of Gaens Quarry) and Lafarge-Tarmac (Grove and Cornelly Quarries) to consider the hydrology and hydrogeology of the area. In order to consider uncertainty about the risk of impacts occurring, the quarry operators have invested in a major programme of investigation, monitoring and analysis aimed at reducing this uncertainty. The results of this work are presented in this chapter and supported by a series of Appendices: 7/1 (Volume 2A); 7/2, 7/3 and 7/4 (Volume 2B); and 7/5 (Volume 2C).

7.2 Scope

7.2.1 Scoping Direction

The Welsh Government issued a Scoping Direction for the EIA / Environmental Statement to support the ROMP Review application for new planning conditions at Gaens Quarry on 3 March 2013 (ref A-PAA-25-08-004 – See Appendix 1/1). In summary, with respect to hydrology and hydrogeology this stated that:

The ES should include an updated and refined conceptual model, using all the data collected to date, which will underpin the assessment of potential impact from the dewatering operations on end receptors such as the Kenfig SAC and Cefn Cribwr Grasslands SAC and the Swansea Southern Carboniferous Limestone groundwater (Water Framework Directive) body, which is classified as being of poor status as a result of risks from saline intrusion, water abstraction and flow regulation, diffuse source pollution and terrestrial ecosystems.

The issues which should be addressed include:

- *the potential impact of quarrying on Kenfig/Cynffig SAC/SSSIs and Cefn Cribwr Grasslands SAC/SSSIs;*
- *the potential impact of quarrying on hydrology and hydrogeology of the area, including the possibility of interception during quarrying of a 'highly permeable feature' within the limestone, and although there is a low probability of this occurring the prospect should be recognised as a continuing risk during further development of the quarry and appropriate action identified (for example a risk management/monitoring strategy which recognises the critical stage at which potential adverse impact may occur);*
- *the potential impacts on the Kenfig/Cynffig SAC and the hydrology of the dune system and Kenfig Pool, including the nature of the hydraulic connection between the dune sands and the underlying sand and gravel aquifer at Cynffig/Kenfig SSSI and the related sensitivity of groundwater levels in the dune sands to drawdown in the sand and gravel aquifer;*
- *the potential impacts on other groundwater users and water features in the area;*
- *the potential for quarry dewatering to induce saline intrusion into the aquifer;*

- *the likely impact from further quarrying on the migration of leachate and landfill gas;*
- *the likely impact of quarrying on the stability of surrounding land;*
- *an evaluation of potential surface lowering and sinkhole collapse.*

The ES should include a refinement of the water management plan, which should include a description of water management measures at the quarries, linked to the proposed works, quarry development, quarry decommissioning and reinstatement and set out the monitoring programme, a description of any necessary remedial strategy and any actions the operator would take to prevent and/or reverse any impacts. This should facilitate the improved understanding of the regional and local water regime and the nature of any uncertainty which might remain.

In relation to predicted effects of future quarry development, potential effects that need to be considered and explained include:

- general effects on groundwater levels and flows and loss of groundwater resources.
- derogation of existing or planned groundwater abstraction wells and boreholes
- impact on surface watercourses and wetlands
- impact on flora and fauna
- implications of subsequent water table rebound
- saline intrusion caused by changes in groundwater flow paths
- subsidence and settlement caused by falling groundwater levels
- water flows from proposed discharge points
- timing *and duration of any impacts*

7.2.2 Background

The Quarries

Gaens Quarry lies immediately to the north west of Cornelly Quarry and covers a total permitted consented area of approximately 13 ha. The quarry floor is currently at around 11 mAOD with a sump at 9 mAOD.

Production at the neighbouring Cornelly Quarry began circa 1875 and the quarry has since developed into the largest quarry in Wales, providing over 1 million tonnes of limestone per year, principally for the steel mill at Port Talbot. The total area covered by existing consents for mineral extraction is approximately 76 ha

The main quarry floor is currently at around -2 mAOD with a sump at -5 mAOD. Cornelly Quarry is dewatered by pumping from a sump in the quarry floor. This lifts water to a settlement lagoon which is also used to re circulate water used in processing stone on site. Water is also pumped directly to Grove Quarry and re-infiltrates into the Carboniferous Limestone aquifer by seepage through the floor and sides of this flooded quarry. Water has also been pumped to Pant Mawr Quarry and Stormy Down Quarry in the past.

Grove Quarry lies about 1 km to the west of Cornelly. The total area covered by existing permisions for mineral extraction at Grove is approximately 30 ha. When worked, the quarry requires only occasional dewatering; water is discharged to a disused railway cutting to the west as required. The quarry floor is currently at around 30 mAOD. The quarry is currently not operational.

Planning Context

In 1997, applications were made to Bridgend CBC under the Terms of the Environment Act, 1995 (Review of old mineral permissions, ROMP), for determination of a scheme of conditions for:

- Gaens Quarry (operated by T S Rees Limited
- Cornelly Quarry (operated by Cambrian Stone Limited);
- Grove Quarry (then operated by Pioneer Aggregates (UK) Limited, now owned by Lafarge Tarmac Limited);

The Gaens Quarry application was called in by the Secretary of State for Wales in May 1998 and the Cornelly and Grove Quarry applications were called in in June 1998. The reasons for these decisions were largely related to concerns about the potential effects of dewatering the quarries on the local environment. The National Assembly for Wales (now the Welsh Government) subsequently took on the role of determining authority for the applications.

In December 1999, the National Assembly for Wales instructed the British Geological Survey (BGS) to produce a report covering the hydrological issues related to the continued operation of the Cornelly Group of Quarries. In August 2000, the National Assembly for Wales requested the preparation of voluntary Environmental Statements (ESs) to assist in the determination of the Environment Act submissions.

In May 2001 ESI Ltd was appointed by the operators of the three quarries (the Applicants) to carry out appropriate investigations and to prepare environmental statements presenting hydrogeological impact assessments for the three quarries.

For reasons explained in Chapter 1.0 of this ES, the respective applications have not been determined, and there is a requirement to undertake further updated EIA's and to present the results in updated formal ES's. This chapter of the ES comprises an update of the previous hydrogeological impact assessments, informed by ongoing discussions with the EA and CCW, and more recently NRW (hereafter referred to as the regulators).

7.2.3 Study area

The study area is shown on Figure 7.1. The three quarries are situated on an elevated area of land (up to 100 m AOD) south of Junction 37 of the M4 (Pyle) and immediately to the south and east of the village of South Cornelly. To the west and south west of the quarries, the ground falls steeply to an area where low, rolling ground slopes gently to the sea. There are two large areas of sand dunes close to the coast to the north west (Kenfig) and south (Merthyr Mawr) of this upstanding block of limestone.

The northern edge of the upstanding block of limestone is cut by the M4. To the north of this the ground falls steeply to the valley of the Afon Fach, which runs through the town of Pyle and joins the Afon Cynffig to the west. The high ground extends eastward through Laleston towards Bridgend where it is cut by the valley of the Ogmore River.

A disused quarry and lime works is situated just over 2 km to the north east of Gaens Quarry and to the north of the M4. A further disused quarry (Stormy Down) is located immediately to the east of Gaens Quarry; this is now flooded to a considerable depth.

Two former municipal landfills are located in old quarries to the east and south of Gaens Quarry (Stormy West and Tythegston Landfills respectively). The locations of these landfills are shown on Figure 7.1. Both landfills were closed in the late 1990s and subsequently capped. Neither landfill is lined, both having been designed as dilute and disperse sites.

7.2.4 Approach to the Hydrology/Hydrogeology Assessment

As discussed above, when the Gaens ROMP application was first called in, there was a significant degree of uncertainty as to the risk of impacts from quarrying activities, particularly with respect to the Kenfig/Cynffig (then candidate) SAC/SSSIs. Due to the wording of the Habitats Directive (and subsequent case law) which protects these sites, the level of certainty required for the assessment is very high: the Waddenzee Ruling (European Court of Justice Case C-172/02, 2004) clarifies the requirements of the Habitats Directive, specifically the need for certainty that the project will not adversely affect the integrity of the SAC site to the point that "no reasonable scientific doubt remains".

As a result, the key challenge for the hydrological / hydrogeological impact assessment was to reduce the pre-existing uncertainty about how the local groundwater system behaves and for the associated ecological impact assessment to draw upon this information in reaching informed scientifically robust conclusions regarding possible indirect impact on the SAC.

The objective to reduce uncertainty is acknowledged to be constrained by the nature of groundwater flows in limestone systems where some element of uncertainty will always remain. The task is thus to reduce that uncertainty as far as is practicably possible, and to then consider the extent to which any remaining limited uncertainty influences the impact conclusions or whether residual uncertainties can be addressed by other means. The approach adopted was as follows:

1) Reduce uncertainty in conceptual model and water balance by field investigation and monitoring. This was carried out in a phased manner (see Section 7.2.4) so that the results of each phase could be used to refine and focus subsequent phases.

2) Reduce uncertainty further by construction of a detailed flow network model which allows consistent treatment of groundwater flows within the system and is calibrated to observed flow and heads (Section 7.5.2).

3) Further reduction of uncertainty by extensive sensitivity analysis. Where parameter values could not be fully constrained, these were taken forward to the predictive scenarios (Section 7.5.2).

4) The Scoping Direction requires the assessment to address *the possibility of interception during quarrying of a 'highly permeable feature'.* Although not consistent with the conceptual model and calibrated flow network model presented in this report, this issue must therefore be addressed in the assessment. The issue is therefore discussed at several points in the text below but ultimately this risk is addressed by means of a revised Water Management Plan which specifies the monitoring required and the Contingency Measures that should be taken if such a feature were to be encountered.

Each of these phases was carried out in close consultation with the regulators. This phased process has provided the opportunity to reduce the level of uncertainty in the assessment to a level that allows the related ecological impact assessment to draw conclusions which meet the exacting requirements of the Habitats Directive.

7.2.5 Programme of Work

Submission of first set of ESs (up to September 2009)

The report prepared by BGS on behalf of the National Assembly for Wales (BGS, 2000) made a number of recommendations for further investigations that could be carried out in order to clarify the local hydrogeology at the level of detail required. The approach recommended by BGS was reviewed by ESI and was considered to be too prescriptive: instead a phased approach was proposed. This revised approach was discussed with the regulators and submitted to the Welsh Government in July 2001 as an informal 'Scoping Request' (ref ESI, 2001).

The phased approach that was adopted for the investigations was designed to allow the key uncertainties in the conceptual understanding of the study area to be identified at the start of each phase (in discussion with technical experts from the relevant regulatory bodies). The investigations in each phase were then designed in order to maximise the opportunities to reduce these uncertainties. Close liaison with the regulators on these issues has guided the design of each phase of work.

The work was carried out in three main phases:

> **Phase 1** (water features survey, spot gauging, geophysics and construction of additional monitoring boreholes) was completed in late 2001. An interim factual report was prepared to integrate the findings of Phase 1 into the existing conceptual understanding of the area (ESI, 2002a). The aim was to highlight aspects of the conceptual model for which uncertainty still existed. This provided a target for investigations during Phase 2 (ESI, 2002b).
>
> **Phase 2** (additional drilling, tracer test and continued monitoring) took place during the summer and autumn of 2002. A factual report summarising all the work carried out under Phase 2 and the results of monitoring to date was issued at the beginning of March 2003 (ESI, 2003a).
>
> **Phase 3** Building on the data gathering and collation work undertaken during both Phases 1 and 2 of the study, a conceptual hydrogeological model of the area was developed (ESI, 2003b). The purpose of this report was to set out the conceptual model of the local hydrogeology. This conceptual model was used for quantifying the likely impacts of quarry dewatering and as much of the technical basis for the first impact assessment for each quarry. The conceptual model report also provided the baseline data for the first impact assessment.

Following submission of the conceptual model report, several meetings were held with the technical experts from the relevant regulators (principally EA Wales and CCW) in order to clarify all aspects of the conceptual model. Further details of the approach adopted to some of the calculations were also submitted at that time (ESI, 2003c). Confirmation was received that all information to support the conceptual model was adequately described (Environment Agency, 2003a and b).

During the process of reviewing the voluntary Cornelly Quarry ROMP ES (which was submitted in October 2004), EA Wales made further comments on the conceptual model and provided a draft report on the nitrogen budget for Merthyr Mawr which contained some information relevant to the hydrogeology of the area (Jones et al 2005). EA Wales commissioned some further work on the Merthyr Mawr Blown Sand dune system and draft outputs were provided. Key elements relevant to these reports are discussed in Section 7.4.1.

In total, three impact assessment reports were produced, each covering the potential impacts relating to one of the three quarries in isolation as well as the combined effects of working all three quarries in conjunction. These are summarised in Table 7.1 below:

Table 7-1 Impact Assessment Reports

Report title	Report content
Cornelly Group of Quarries: Impact Assessment for Cornelly Quarry and Combined Quarries (ESI, 2004)	Quantified assessment of the likely impacts on a targeted list of water features, resulting from proposed quarry development activities at Cornelly Quarry alone and also in response to combined quarry development activities at Cornelly, Grove and Gaens quarries.
Cornelly Group of Quarries: Impact Assessment for Grove Quarry (ESI, 2008)	Quantified assessment of the likely impacts on a targeted list of water features, resulting from proposed quarry development activities at Grove Quarry.
Cornelly Group of Quarries: Impact Assessment for Gaens Quarry (ESI, 2010) – Unsubmitted draft.	Quantified assessment of the likely impacts on a targeted list of water features, resulting from proposed quarry development activities at Gaens Quarry.

In addition a combined impact assessment report was produced for the Periodic Review of the IDO permission covering parts of Cornelly and Grove quarries (WYG, ES January 2009).

Discussion on the scope and content of the Water Management Plan for Cornelly Quarry continued up until June 2009 with several iterations being submitted for review by the regulators with comments being addressed in subsequent iterations.

A summary of reports and studies prior to the new Scoping Directions is provided in Section 7.4.1.

Submission of second set of ESs (up to present)

The ROMP process stalled following the submission of the first set of ESs until March 2013, when new Scoping Directions were issued for each of the quarries by the Welsh Government under the Town and Country Planning Act (Environmental Impact Assessment) (Undetermined Reviews Of Old Minerals Permissions) (Wales) Regulations 2009.

These are summarised in Section 7.2.1 and provided in full in Appendix A of Appendix 7/1. These form the context for the work presented in this ES including the Revised Conceptual Model Report presented in Appendix 7/1.

A key requirement of the Scoping Direction is for the conceptual model to be updated to take account of new data and for all the work to be brought together into a single coherent structure. The additional work incorporated into and carried out for the revised conceptual model was:

- Review of recent monitoring data (groundwater levels, surface water flows, quarry pumping, chemistry and climate data);
- Incorporation of additional borehole data;

- An updated palaeokarst survey;
- A review of rainfall and recharge calculations;
- A revised approach to modelling of the system which included explicit simulation of groundwater within the Kenfig and Merthyr Mawr Blown Sand aquifer systems in transient (rather than steady-state) mode.

7.2.6 Consultation

As noted above, the programme of investigation has been designed, implemented and reviewed in close consultation with technical experts from the regulatory authorities, particularly NRW (and its antecedents). The following meetings were held during the course of the Phase 1, 2 and 3 investigations:

Table 7-2 Summary of Meetings for Phase 1, 2, and 3 Investigations

DATE	MEETING / CORRESPONDANCE
29-May-01	Meeting to discuss Phase 1 report and proposals for Phase 2.
08-Jun-01	Meeting with CCW to discuss citation details of SAC and monitoring data
21-Jun-01	Meeting with Agency to discuss approach to investigations and EIA
03-Jul-02	Technical meeting to review Phase 1 report and proposals for Phase 2.
23-Oct-02	Technical meeting to discuss results from Phase 2 and need for any more work.
31-Oct-02	Full meeting to discuss results from Phase 2 and need for any more work.
19-Aug-03	Full meeting to discuss conceptual model report.
16-Oct-03	Full meeting to discuss conceptual model report.
07-Nov-03	Technical meeting to discuss conceptual model report.

Following the issue of the first voluntary ES in support of the Cornelly Quarry ROMP application (October, 2004), there was a period of correspondence between the various parties to clarify various parts of the hydro assessment. This included a meeting on 4 May 2005 between staff from ESI and WMC (the consultants appointed by EA Wales to review the technical aspects of the impact assessment) to discuss the water balance model that forms the technical core of the impact assessment. EA Wales issued its formal response to the first ES in support of the Cornelly Quarry ROMP application in July 2005 and ESI subsequently provided the results of further detailed calculations and clarifications, as summarised in Table 7-3 below.

Following submission of the first voluntary ES and draft WMP, a series of discussions and exchanges of correspondence took place between representatives of the Applicants (ESI) and the regulatory bodies, notably EA Wales, CCW and the National Assembly for Wales. A summary of those exchanges is set out in Table 7-3 below.

Table 7-3 Consultation on WMP

DATE	MEETING / CORRESPONDANCE
28.10.04	Meeting between the National Assembly for Wales, EA, CCW, BCBC and Applicants to review content of ES and first draft WMP.
28.01.05	Meeting between National Assembly for Wales, EA, CCW, BCBC and Applicants to progress discussions on ES.
23.02.05	Letter from EA to Applicants requesting clarification of technical data and submission of water balance spreadsheets.
11.03.05	Response from ESI with further data supplied by email on 04.04.05.
11.03.05	Letter from CCW to Applicants relating to, *inter alia*, significance of changes in water levels in the Blown Sand aquifer system, and the content of the WMP and mitigation strategy.
25.05.05	Letter from EA requesting additional data in support of the hydro study.
09.05.05	Letter from ESI to EA with the requested data.
04.07.05	Letter from EA raising further queries and providing report on Merthyr Mawr.
11.07.05	Preliminary response from ESI to EA.
23.11.05	Letter from ESI to EA with requested further hydrological calculations.
03.10.05	Reply from EA with particular reference to timescale of water level recovery following cessation of dewatering.
14.11.05	Letter from WYG to the National Assembly for Wales with comments on the letter from the EA of 03.10.05.
01.12.05	Letter from WYG to the National Assembly for Wales, with comments on the CCW letter of 11.03.05.
24.04.06	Letter from CCW to the National Assembly for Wales, cross-referencing letter dated 05.10.05 from CCW to the National Assembly for Wales.
26.05.06	Letter from WYG to the National Assembly for Wales.
18.07.06	Letter from EA to the National Assembly for Wales, requesting further details/ clarification of groundwater model and assumptions, and suggested alterations to the WMP.
19.07.06	Meeting to discuss current position and outstanding issues attended by CCW, EA, National Assembly for Wales and Applicants, where the key focus was on the need for an updated WMP.
14.08.06	Technical meeting to discuss content of WMP attended by ESI, EA and CCW.
25.09.06	Further technical meeting to review draft WMP (V1.1) attended by ESI, EA and CCW.
23.10.06	Circulation of revised draft WMP (V1.2) to the National Assembly for Wales, CCW, EA and BCBC.
16.01.07	Technical meeting attended by ESI, EA and CCW to discuss draft WMP.
19.09.07	Formal submission of revised and updated WMP (ref August 2007) to the National Assembly for Wales, CCW, EA and other interested parties.
Oct-08	v3.1b Cornelly WMP submitted in response to WAG Jun 08 comments
Sep-09	v3.1c Cornelly WMP submitted with combined Cornelly Grove IDO EIA

Following revival of the ROMP process in March 2013, a series of communication and meetings were held with NRW to allow involvement with the process of revision of the conceptual model and numerical model development and to keep relevant technical experts up to date with the proposed approach and results of modelling of quarry development scenarios. These interactions are summarised in the table below:

Table 7-4 Post March 2013 Consultation with NRW

DATE	MEETING / CORRESPONDANCE
19.06.13	Initial meeting to allow acquaintance of new ES and NRW team; confirm issues outstanding; discuss levels of assessment and the requirements of the habitats directive; dealing with uncertainty
13.08.13	Cornelly site visit. Discussion with focus on outstanding hydrogeological issues.
11.10.13	Issue conceptual model report for review.
25.10.13	Presentation and discussion of conceptual model.
08.11.13	Further technical discussion on the conceptual model and focusing in on the numerical model.
02.12.13	Presentation and discussion of quarry development model prediction runs.
14.02.14	Presentation of impact assessment results and conclusions.

7.3 Proposed Development

7.3.1 Quarry Development

Summary details of the proposed development of all three quarries are shown in Table 7-6 Proposed Quarry Development- Cornelly Quarry

to Table 7-5 Proposed Quarry Development – Gaens Quarry

. In addition, the proposed development plans for all three quarries are shown in Appendix B of Appendix 7/1.

The proposed development of Gaens quarry is summarised in Table 7-5. Final excavation levels are based on SLR drawing 3782/05 dated January 2014. The final development represents approximately 50 years of working.

Table 7-5 Proposed Quarry Development – Gaens Quarry

Timescale	Planned Excavation	Comments
Present day	Deepest level at around 9 mAOD.	Current situation
Phase 1 (1-10 years)	Extraction to -20mAOD within western part of Quarry	Quarry sump expanded
Phase 2 (11-30 yrs)	Extraction to -20mAOD within south-eastern part of Quarry	As Phase 1
Phase 3 (31-40 yrs)	Extraction to -20mAOD within western part of Quarry	Temporary sump created in eastern part of void

Timescale	Planned Excavation	Comments
Phase 4 (41-50 yrs)	Extraction to -20mAOD within eastern part of Quarry.	As Phase 3.

The proposed development of Cornelly quarry is summarised in Table 7-6.

Table 7-6 Proposed Quarry Development- Cornelly Quarry

Timescale*	Planned Excavation	Comments
Stage 0 (Present day)	Main quarry floor at -2 mAOD	Current situation
Stage 1 (0-5 years)	Main quarry floor at 0 to -3 mAOD. Expansion of lowest level northwards and working of northern benches.	Quarry sump at -15m AOD
Stage 2 (5-10 years)	Lowest floor level at –15 mAOD. Working of north western, eastern, and south eastern parts of the quarry.	Quarry sump at -30m AOD
Stage 3 (10-15 years)	Lowest floor level at –30 mAOD. Working of central area of quarry.	End current ROMP cycle position
Stage 4 (15-30 years)	Lowest floor level at –75 mAOD. Working of central, southern and western areas of quarry.	
Stage 5 (30-42 years)	Lowest floor level at –75 mAOD. Working of central, southern and western areas of quarry.	42 years represents the end of the planning permission.

* Timescales measured from August 2013

The proposed development of Grove Quarry is summarised in Table 7-7.

Table 7-7 Proposed Quarry Development – Grove Quarry

Timescale	Planned Excavation	Comments
Present day	Deepest excavation around 12 mAOD.	Current situation
15 years	Excavation to -15 mAOD	Worst case
42 years	Excavation to -15 mAOD	Worst case

7.3.2 Quarry Decommissioning

All three quarries will ultimately be restored to open bodies of water. The likely position to which water levels will ultimately recover has been assessed as part of this impact assessment.

Substantial volumes of water are required to fill the quarry voids (particularly Cornelly Quarry) and the period during which this recovery is occurring has been flagged by this assessment as a potentially critical period for impacts to occur. It is important that monitoring of the environment continues after the end of normal operation at the quarries until it can be demonstrated that no significant impacts are likely to occur. Some form of residual pumping for several years after the end of extraction may be required to mitigate any such impacts.

7.4 Baseline Conditions

The baseline hydrogeology of the study area has been described in a series of reports issued by ESI (see Table 7-8). Key reports are the original conceptual model report (ESI, 2003b) and that presented in support of this assessment (Appendix 7/1). These present baseline conditions, including local surface water features, geology, hydrogeology (groundwater levels and flows), hydrochemistry, land use, water users and other relevant human activities.

Current conditions do not represent a true baseline in that the quarries have already been substantially developed, and Cornelly Quarry is being dewatered to a substantial depth. However, this assessment indicates that the effect of current dewatering is limited to a relatively small area around the quarries and that, for most of the rest of the area, current conditions are a good approximation to baseline conditions. The long time series of data collected at most monitoring sites supports this conclusion.

Very small 'theoretical' effects (i.e. below the resolution of available monitoring techniques) are simulated over a broad area by the flow network model developed for this assessment (Appendix 7/3). These effects are discussed in detail in Appendix 7/4.

7.4.1 Previous reports

A summary of relevant reports and studies to date is presented in Table 7-8 below.

Table 7-8 Reporting History prior to submission of first set of Impact Assessment Reports

Report title	Report content
Scoping Request - Hydrology and Hydrogeology (ESI, 2001)	The response to an informal scoping request by the National Assembly of Wales in respect of proposed Environmental Impact Assessments (EIAs) being undertaken for the group of quarries near Cornelly. This scoping report relates only to environmental issues linked to the water environment (hydrology and hydrogeology). A preliminary conceptual model of the hydrogeology of the study area is included.
Cornelly Group of Quarries: Proposed Programme of Work for Phase 2 Hydrogeological Investigations (ESI, May 2002a) Report Reference 6227R2D2	Outlines a proposed programme of borehole and water feature monitoring across the study area, designed to address a range of hydrogeological uncertainties relating to the conceptual groundwater system.

Report title	Report content
The Hydrogeology of the Area Around the Cornelly Group of Quarries (ESI, May 2002b) Phase 1 Report Reference 6227R3D2	A factual summary of the data collected during Phase 1, including information concerning local geology, hydrology, formation properties, key water features, and general groundwater conditions. The data are drawn together to illustrate the preliminary conceptual model of the hydrogeology of the study area. Key uncertainties in the conceptual model are highlighted.
Hydrogeological Investigations at the Cornelly Group of Quarries: Factual Report on Phase 2 (ESI, March 2003a) Report Reference 6227R4	Sets out the results of the Phase 2 work including a report on the tracer tests by Prof P Smart. No attempt is made to refine the conceptual model of the area although some interpretation of the geology in the vicinity of Kenfig Pool is undertaken.
Cornelly Group of Quarries: Conceptual Model of the Local Hydrogeology (ESI, July 2003b) Phase 3 Report Reference 6227R5D1	Presents the conceptual model of the hydrogeology of the area based on all of the work to date. A key part of the report is the identification of any significant uncertainties in the conceptual model and discussion of how these will affect the approach to the impact assessment.

In addition, annual reports in the format consistent with the requirements of the Water Management Plan (Appendix 7/5) have been prepared since 2007. These present the baseline data in detail and discuss trends on a year by year basis.

7.4.2 Geology

A detailed description of the geology can be found in Appendix G of Appendix 7/1. A summary is provided below.

Regional Geology

Solid Geology

The key solid geology formations are:

- Triassic Mercia Mudstone: Coarse grained, conglomeratic marginal facies (aquifer) and distal mudstone facies (non aquifer);
- Carboniferous Limestone: A variable sequence of limestones, shales and sandstones. The most layered, shaley units are concentrated at the top and bottom of the sequence. The main limestones worked at the quarries comprise the Cornelly Oolite and Stormy Limestone (Cornelly and Grove) and the overlying Oxwich Head Limestone (Gaens quarry).

The mapped extent of these strata and associated cross sections from the BGS (2000) are shown on Figure 3.1 and 3.2 respectively in Appendix 7/1.

The Carboniferous Limestone which is worked by the quarries forms the main aquifer in the area, and is classified as a Major Aquifer by NRW for the purposes of groundwater protection. The Carboniferous Limestone forms the higher plateau around the quarries.

Other formations form minor aquifers (e.g. the blown sand deposits at Kenfig and the Triassic Mercia Mudstone Marginal Facies) or non-aquifers (e.g. the Mercia Mudstone (undifferentiated) and the estuarine clays and silts at Kenfig).

The major unconformity between the Carboniferous strata and the overlying Triassic deposits is a significant feature of the local geology. The exposure of the limestone to erosion and karstification during this period is discussed below and in Appendices G and H of Appendix 7/1.

The Carboniferous strata dip to the north at 0 to 40^{o} exposing progressively younger strata to the north. The sequence is also disrupted by the north west - south east Newton Fault and associated splays. To the north, the sequence is truncated by the east-west Triassic Boundary Fault which downthrows Triassic Mudstones and Upper Carboniferous Coal Measures strata.

Superficial Geology

The superficial deposits in the study area are shown on Figure 3.3 of Appendix 7/1. The main units of significance at outcrop are:

- Blown sands: The dune fields at Kenfig and Merthyr Mawr comprise loose, fine-grained sand with shell debris.
- Estuarine clays and alluvium (organic rich clays and silts with beds of peat) underlies the blown sands at Kenfig. At Merthyr Mawr a thin 1-3 m thick clay layer underlies the Blown Sands.
- Till: Much of the area around Pyle is underlain by relatively impermeable Diamicton and gravelly, clayey sand.
- Glaciofluvial deposits. Predominantly sand and gravel forming a minor aquifer. This underlies the estuarine clays at Kenfig. In places this lies directly on the Triassic marginal facies or Carboniferous Limestone thus providing a potential pathway between the main aquifer system and groundwater in the superficial deposits.

Local Geology

Kenfig

A schematic diagram of the evolution of Kenfig Pool is shown in Figure 3.4 of Appendix 7/1 (BGS, 2000).

The nature of the superficial deposits in this area is of critical importance to the understanding of the degree of connection between the Blown Sand hydrological system and that of the underlying Triassic and Carboniferous strata. This in turn has implications for the potential for dewatering at the Cornelly Group of quarries to affect groundwater levels at Kenfig. The superficial geology around Kenfig was the focus of much of the geological and geophysical investigations carried out as part of the current assessment by the operators and has been the subject of detailed discussions between ESI and the regulators. Wherever possible uncertainties have been resolved by investigation, but the remaining residual uncertainties have been taken through to sensitivity analysis on the predictive model runs.

A detailed review of the local geology presented in Appendix G of Appendix 7/1 concludes that the low permeability estuarine clays and alluvium is present throughout the main area in which the overlying Blown Sands are saturated. The estimated thickness of this layer and the lateral extent of saturated Blown Sands are shown on Figure 3.5 of Appendix 7/1.

Merthyr Mawr

The system at Merthyr Mawr had not been studied by external sources in as much detail as Kenfig at the start of the operations investigations. The SAC has subsequently been investigated in detail by the regulators (as reported in CEH, 2005 and SWS, 2010). Within the SAC, Blown Sand overlies Friar's Point Limestone over most of the area. In the west there is a small area of subcrop of Mercia Mudstone Marginal Facies and in the east, around Candlestone Stream, there is a small outcrop of Brofiscin Oolite Formation and Barry Harbour Limestone Formation. Beneath the Mean High Water line the outcrop is predominantly marine beach deposits of sand with some outcrop of limestone in the west. A strip of Tidal Flat Deposits follows the line of the River Ogmore.

The main area of humid dune slacks within the Blown Sand is in the southern and eastern part of the SSSI. In the north, the dunes overlie a step in the underlying limestone, roughly parallel with the coastline. To the north of the step, the dunes are considered to be 'dry' with no active dune slacks. Limestone has also been observed cropping out in a number of places along this step (BGS, 1:10,000 geology maps).

Borehole logs and augering have demonstrated the occurrence of a 1-3 m thick clay layer separating the sands from the underlying limestone in the central part of the dune system (south of the step in topography). Beneath the sand in the west, gravels are present, rather than clay: gravel workings west of Burrows Well confirm this. Gravel was also encountered close to the Candlestone Stream channel and to the River Ogmore in the east.

The low elevation of the top of the limestone in the east indicates the presence of a possible buried channel associated with the River Ogmore.

Structure

The locations of key faults in the area are shown on the solid geology map (Figure 3.1 of Appendix 7/1) and on cross sections through the area (Figure 3.2 of Appendix 7/1). The study area lies on the southern edge of the South Wales syncline. The quarries themselves lie on the northern limb of the Candleston Anticline, a subsidiary fold in this system.

The most prominent structural feature in the area is the north west - south east trending Newton Fault which down throws Triassic strata to the south west. A series of NNW-SSE trending cross faults, which include the Morfa Fault, link into the Newton Fault to the west of the quarries. South of the quarries, the Newton Down Fault Zone comprises a complex set of east-west reverse faults. The east-west Kenfig and Triassic Boundary Faults act as opposing normal faults which downthrow Triassic and Jurassic strata in a trough to the north of the quarries.

7.4.3 Hydrology

Rainfall

The NRW has provided data for the rainfall stations at:

- Margam (SS808856, about 4 km to the north of the quarries) for the period February 1991 to June 2013,
- Cefn Cribwr (SS856838, about 3 km to the north east of the quarries) for the period January 1981 to January 2009; and
- Schwyll from December 1991 to June 2013.

Long term average rainfall at Margam is 1149 mm/a with 1996 being the driest year in the 22 year sequence (845 mm) and 2012 being the wettest (1655 mm). The very wet sequence of months from April 2012 onwards affects most of the recent water level records.

Evapotranspiration and Recharge

From MORECS potential evapotranspiration (PE) data the long term average PE is 644 mm/a (2002-2012). PE is less variable from year to year than rainfall. However, the wet weather in 2012 coincided with a low PE (614 mm) which will enhance recharge in this period.

Recharge to the groundwater system has been calculated using a Penman two store soil moisture balance model implemented in an Excel spreadsheet. The approach was adapted for the calculation of climate based assessment criteria (CBAC) as required for the draft Water Management Plan. This yielded a range of recharge values for different borehole locations as follows:

Table 7-9 Recharge values at various borehole locations

Site	Rain gauge	LTA recharge (mm)	Comment
B-a	Cefn Cribwr (95%)	761	Temporal pattern of Cefn Cribwr worked better than Margam
CC_5	Margam	587	Drying constant reduced to 40 mm to reflect the thin soils

Site	Rain gauge	LTA recharge (mm)	Comment
G	Cefn Cribwr (110%)	973	
South Cornelly	Cefn Cribwr	830	
Porthcawl (using S Cornelly)	Average of Margam and Schwyll	533	
Merthyr Mawr	Schwyll	557	drying constant reduced to 40 mm to reflect the thin soils

Further details are described in Appendix I of Appendix 7/1.

Stream Flows

Available stream flow data for the area are described in Appendix J of Appendix 7/1.

The main surface water flows of interest relate to the two large springs in the area:

- The large, perennial springs at New Mill Farm have been identified as an important feature of the local hydrology and flow measurements have been made on numerous occasions over the last ten years (Appendix J of Appendix 7/1). The spring complex comprises a main spring (20 to 70 l/s, 1,700 to 6,000 m^3/d) sourced from underlying Triassic strata and numerous other smaller seeps and springs in this general area. The total gain in the reach around the springs is around 190 l/s (16,400 m^3/d) although some of this is derived from the surface water catchment of the reach.

- A flume and data logger have been installed by Lafarge-Tarmac on Burrows Well, the Carboniferous Limestone spring that rises in the middle of T.S. Rees Limited Merthyr Mawr dunes (Appendix J). The data show that the spring is ephemeral with flows up to 350 l/s (30,000 m^3/d) but more typically around 50 l/s (4,300 m^3/d).

In addition to these flows, there is some surface water flow in the dune slacks at Kenfig during high groundwater level conditions (Jones, 1993). However, this all recharges to the Blown Sands to the west rather than flowing to the coast.

The majority of the effective rainfall in the area discharges via groundwater to the sea in a way such that it cannot be measured. As a result, the water balance of the aquifer cannot be constrained by measured data, hence the need for a transient flow network model. Uncertainties in the water balance have been dealt with by sensitivity analysis on the flow network model, varying recharge within a range that is considered to be physically realistic (+/-15%).

7.4.4 Hydrogeology

Relevant Formations and their Properties

Two types of aquifer are present in the study area: porous medium aquifers, in which flow is distributed relatively evenly throughout the whole formation (e.g. the Blown Sands of the sand dune systems) and karstic aquifers in which flow occurs almost entirely through solution enhanced fissures or conduits (e.g. the Carboniferous Limestone and Triassic Marginal Facies).

The type of flow associated with the aquifer dictates the most appropriate approach to the assessment of baseline conditions and potential impacts in the aquifer:

- In porous aquifers, flows are well defined by existing groundwater flow equations. Definition of the physical extent of the aquifer and a few key properties (e.g. hydraulic conductivity) allows predictions of impact to be made with a high degree of confidence;

- In contrast, in karstic aquifers the flows and potential for impact are almost entirely controlled by the nature and distribution of the conduits which cannot be physically constrained with any degree of certainty by field measurements. Furthermore, the equations governing flows in such a system are much more complex than for a porous medium and are highly sensitive to the detailed nature of the conduit system.

As a consequence, whilst porous medium equations are commonly applied to karstic aquifers for the purposes of scoping calculations, the degree of confidence in the resultant predictions is generally low. It is therefore generally accepted that the most appropriate approach to the investigation of karstic systems is not to attempt full parameterisation but rather to try and understand the nature and distribution of the conduit system at a larger scale (through tracing experiments (Appendix M of Appendix 7/1), measuring spring flows (Appendix J of Appendix 7/1) and carrying out lumped water balances (Appendix 7/3)). This understanding can then be used to make a qualitative (or semi-quantitative) assessment of potential impacts and to identify appropriate monitoring measures to check for their occurrence. Due to the associated uncertainties, sensitivity analysis is required for any calculations presented.

The available groundwater level data have been interpreted to derive estimates of aquifer properties (Appendix G of Appendix 7/1). These give a broad indication of the contrast in properties between the different formations:

- Jones, 1993 carried out tests on the blown sands which suggested that the mean hydraulic conductivity was around 9 m/d. Calculations based on observed hydraulic gradients and estimated recharge suggest that the value could be higher than this (up to 25 m/d);
- A wide range of values of bulk transmissivity have been estimated for the Carboniferous Limestone. In general it is probably around 100 m^2/d but it may be ten times as high between Porthcawl and Grove and only around 25 m^2/d at Cornelly itself.

Post Depositional Influences on Formation Properties

The Carboniferous Limestone is a karstic aquifer in which flow is concentrated in fissures rather than being distributed within the matrix of the formation. Understanding the implications of the general nature and distribution of these fissures is important to the current assessment. The Scoping Direction has also specifically required that *'the possibility of interception during quarrying of a 'highly permeable feature' within the limestone'* is included in the assessment. The risk of encountering such a feature is very dependent on the post depositional history of the limestones as discussed in the following sub sections.

Structure

As well as disrupting and offsetting strata, faults and joints may act as zones of enhanced permeability within the limestone. However, where they are infilled with clayey material, they may also act as zones of low permeability (e.g. in the north-south joints observed in Cornelly quarry).

There is no direct evidence of the role of faults on groundwater flows in the area. However, from consideration of groundwater levels (Appendix K of Appendix 7/1) some indications can be inferred:

- Groundwater levels are generally fairly low to the south west of the Newton Fault and rise steeply to the north east. In addition, Borehole H (located close to the junction of a dry valley and the Newton Fault) shows small tidal fluctuations in water levels despite its distance from the sea (2.5 km). Together, this evidence suggest that the Newton Fault (and possibly the north-south faults running down to Porthcawl) acts as a zone of enhanced permeability.

- As discussed above and in detail in Appendix H, clay filled north-south fissures in Cornelly quarry appear to significantly reduce the transmissivity of the aquifer in this direction such that the water level in Stormy Down Quarry is approximately 75 m higher than the sump level in Cornelly Quarry (only a few hundred metres away).

The New Mill Farm springs appear to be close to a north-south running splay from the Newton Fault and thus their position (and associated focussed zone of high permeability) may be linked to this. However, there are no mapped faults near the similarly sized Burrows Well in Merthyr Mawr and so general rules about mapped fault locations and enhanced flows cannot be made.

Palaeokarst

The Carboniferous Limestone was sub-aerially exposed prior to the deposition of the overlying Triassic strata and during this period extensive karst networks developed in the formation. These karstic voids were subsequently infilled by later, predominantly fine grained deposits. During intervening and more recent exposure of the Carboniferous strata, some of the shallowest of these palaeokarst features have become reactivated, although at depth they remain full of low permeability deposits. The main area showing surface expression of active karst features locally is the outcrop of Oxwich Head Limestone to the north of Cornelly Quarry (e.g. along the line of the M4).

BGS, 2000 suggested that reactivation of pre-existing karst features may enhance groundwater circulation, giving rise to sudden changes in the hydrological regime, and the potential for collapse, and sediment-filled features might impede groundwater flow. The report also advances a particular assumption that the sub-vertical palaeokarst features observed in the area connect to laterally sub-horizontal karst features at depth.

A detailed review of the palaeokarst features in the vicinity of the main quarries has been carried out by Prof. Peter Smart of Bristol University and is presented in Appendix H of Appendix 7/1. This was based on survey data from the quarries collected in 2003 and then again in 2013. This concluded that:

- There is a well-developed active vadose karst in the Cornelly area (i.e. in the unsaturated zone above the natural water table), comprising 8-10 m of epikarst (shallow weathered zone) with frequently spaced vadose drains.

- The present phase of vadose karstification extends down about 40 m from the surface. There is little evidence for integration of the dispersed recharge from the unsaturated zone within a substantive karst conduit network within the segment of the saturated zone made accessible by dewatering in Cornelly Quarry. Rather, due to the very high frequency of dilated joints, the dewatered saturated zone appears to be characterised by diffuse fracture flow.

- The current quarry inflow is via diffuse flow from fractures and fissures, and focussed flow from blast-induced fractures, rare small capacity bedding tubes and local washout of sediment in palaeocaves.

- It is unlikely that a general increase in the risk of karst collapse will occur as a result of further dewatering. There is small possibility that some local subsidence could occur in the vicinity of any discharge point to groundwater. However, this has not occurred in the vicinity of any groundwater discharges in the area over the past 20 years.

In summary, it is considered to be unlikely that there are any active karst features at depth below the Cornelly Quarry and it is unlikely that the palaeokarst features that do exist at depth will be re-activated by quarry dewatering. Thus the risk of *'interception during quarrying of a 'highly permeable feature' within the limestone'* below Cornelly Quarry is judged to be extremely low. This conclusion is taken forward into the Water Management Plan as the most appropriate mechanism for managing this low level, residual risk.

The 2013 survey was extended into Grove, Gaens and Stormy Down Quarries. In general, similar features were noted in these quarries, although there were some local variations. It is considered that the risk of encountering enhanced permeability at depth may be somewhat higher in these two quarries than in Cornelly because:

- Grove Quarry is crossed by several major faults. Previous work (Robert West and Partners, 1998) reported that water strikes were encountered in several boreholes drilled in this area. Water levels in boreholes fell from east to west across the general area although, in the vicinity of the quarry, there was some evidence of a stepped pattern in the levels, possibly related to the position of faults. A series of water strikes are also reported in the nearby South Cornelly borehole at +20 to -7 mAOD and at a final depth of 47 mAOD (72 mbgl). Strikes are also reported at +5 to -16 mAOD (21 to 42 mbgl) in the nearby Grove borehole (Appendix K of Appendix 7/1).

- Gaens Quarry lies predominantly within the Oxwich head Limestone which has been shown to be highly karstified in the M4 nearby. There is also a north-south fault mapped in this area. However, the main karst feature noted in the recent survey of the quarry (Appendix H of Appendix 7/1) was the presence of palaeosols (fossil soil horizons) which appeared to inhibit the vertical flow of water except where they are breached by vertical features.

The depth to which these quarries will be dewatered and the amount by which the water table will need to be lowered is much smaller in Gaens and Grove Quarries than in Cornelly. Pumping rates would therefore be expected to be relatively low. However, as no permanent dewatering has been carried out and pumping rates monitored at these sites there is some uncertainty about this.

The risk of *'interception during quarrying of a 'highly permeable feature' within the limestone'* below Grove and Gaens Quarries is taken forward into the Water Management Plan for each quarry as the most appropriate mechanism for managing this risk.

In terms of the wider groundwater system around the quarries, it is considered, on the basis of the palaeokarst review, that a general model of enhanced permeability in a zone immediately above and below the position of the current water table is applicable. This is supported by a review of the groundwater level hydrographs which shows that groundwater levels in the

Carboniferous Limestone fall rapidly after winter recharge but generally most boreholes show a ‘base’ level to which groundwater levels fall. This ‘base’ level is controlled by the elevation of this zone of enhanced permeability rather than a physical discharge point from the aquifer.

Groundwater Levels

Baseline monitoring

Groundwater levels have been monitored by T.S. Rees Limited in conjunction with Lafarge-Tarmac, the NRW and staff at the Nature Reserves at nearly 60 sites in the area (Figure 5.1 of Appendix 7/1) over the last decade with some sites having up to 16 years of data. This forms an exceptional baseline for the assessment of the impacts of the quarries.

The longer term data series are shown on Figure 5.2 of Appendix 7/1 (all the hydrographs are presented in Appendix K of Appendix 7/1). From this it can be seen that, whilst there has been some local lowering of the water table in the immediate vicinity of the quarry in response to the quarry deepening over this period by around 20 m, no long term declines can be observed in the more distant sites. Indeed, a common feature of all the hydrographs is the particularly high recent groundwater levels in response to a period of wet weather in 2012.

Using hydrographs to understand groundwater conditions

The hydrogeology of the area is complex and, because of the karstic nature of some of the aquifers, groundwater levels provide the best evidence of groundwater conditions and the behaviour of the aquifers.

In order to facilitate the description of the conceptual model and assessment of the potential impacts of the quarries, the area has been divided into a number of groundwater units. Within the units there is generally a very good correlation in groundwater levels between sites. The aim of the review has been to identify areas in which either the processes occurring appear to be relatively uniform or in which a variety of processes are so linked that it is essential to describe them together. The groundwater levels in each unit are reviewed in detail in Appendix K of Appendix 7/1. The implications of the groundwater level review for various parts of the study area are discussed below.

Kenfig Dunes

The Blown Sands appear to act as a fairly homogeneous system, with groundwater flow radially from a high located to the north west of the pool (see contours on Figure 3.3 of Appendix 7/1).

Annual fluctuations in water level are relatively small (~0.7 m) and maximum levels are, to some extent, controlled by the level of the dune slacks that allow ‘surplus’ recharge to overtop the aquifer during wet periods and flow down the slacks: this can be seen in the ‘flat’ top of some of the hydrographs, particularly near to Kenfig Pool.

However, there is also a significant amount of inter-annual variation in groundwater levels in the dunes: groundwater levels build up slowly over wetter periods and then fall gradually over subsequent years. The summer minimums in the dip tubes monitored at Kenfig have typically varied by around 0.8 m over the last decade (i.e. more variation between years than within years). It is understood that the ecology of the dune slacks may respond to the water levels experienced over several years (say three): the three year rolling average summer minimum values at the dip tubes have varied by an average of 0.4 m over the last decade.

Underlying this Blown Sand system is a series of glaciofluvial sands and gravels. Water levels in these gravels are generally lower than in the overlying Blown Sands and show distinctly different behaviour (Figure 5.3 of Appendix 7/1). This indicates that Kenfig Pool and the Blown Sands are not well connected to this underlying sand and gravel system. This is believed to be because an intervening layer of estuarine clay separates the Blown Sand system from the glaciofluvial deposits.

The glaciofluvial system is not well connected to the underlying 'solid geology' groundwater flow system around the south of the pool but appears to be in closer connection to the north east (borehole N). The glaciofluvial sand and gravels appear to act as a 'sink' for both the overlying Blown Sands and the underlying solid geology at this point.

The direction of groundwater flow within the glaciofluvial deposits is both to the west (towards K1) and to the north (O and River Kenfig). As the area around borehole N is likely to be the main recharge area for the deposits (the only mapped area of outcrop), it is likely that flow is radial from this point with flow both towards the coast to the west and to the River Kenfig to the north.

The glaciofluvial deposits/till around Borehole A acts as a minor, perched aquifer to feed the ephemeral springs that flow to Kenfig Pool.

Merthyr Mawr

In most of the sand dune system at Merthyr Mawr the groundwater levels fluctuate in a similar manner to those at Kenfig. However, in the area to the south of Burrows Well, water levels are affected by the discharge of limestone groundwater into the dune sands which causes large areas of surface water ponding in winter, possibly on a shallow clay layer in this area (SWS, 2010). When the spring stops flowing, these water levels drop rapidly by three or more metres (e.g. piezometer D7) i.e. the groundwater system in this area is not typical of dune slacks more generally. Groundwater gradients are locally occasionally upwards from the limestone to the dune sands (e.g. at Burrows Well) but predominantly downwards.

Elsewhere in the study area:

There is a broad contrast between the coastal areas, in which groundwater heads and seasonal fluctuations are fairly subdued, and the main block of Carboniferous Limestone in which heads rise rapidly away from the edges together with the observed range in fluctuation.

Changes in head in the Carboniferous Limestone appear to coincide with the locations of some of the main fault zones potentially indicating a low permeability across these zones. However, steep gradients are observed elsewhere within the aquifer (e.g. from Pant Mawr to Gaens, Cornelly and Stormy Down) which indicates the presence of zones of low transmissivity.

Hydrochemistry

A detailed review of all the hydrochemical data in the area has been carried out (Appendix L of Appendix 7/1). This has provided a number of insights into the groundwater flow processes occurring is summarised:

- Groundwaters in the study area are all relatively fresh, calcium-bicarbonate type waters with no evidence of deep circulation or long residence times. Seasonal fluctuations in concentration are observed reflecting the flushing of the system with fresh winter recharge water;

- Kenfig Pool is predominantly fed by direct rainfall and Blown Sand groundwater from the north west, although there is a small contribution from shallow seeps to the east which provides water with slightly elevated concentrations of sulphate;

- Water in Cornelly and Grove Quarry sumps has slightly elevated concentrations of sulphate which is believed to be related to oxidation of pyrite in the freshly exposed quarry faces. There have been no long term trends in water quality in the sump at Cornelly Quarry over the last 20 years;

- Groundwater in the immediate vicinity of Stormy West and Tythegston landfills shows the influence of landfill leachate although this does not appear to have migrated any significant distance;

- There appears to be some localised effect on groundwater quality to the north of Gaens Quarry which may be linked to the farm soakaway in this area; and

- Samples from the area around New Mill Farm Springs show a mixture of groundwaters with a strong influence from the Triassic strata.

Groundwater Flow

In a non-karstic system, analysis of groundwater heads gives a good indication of the direction of flow. Around the Cornelly Group of Quarries (where the main Carboniferous Limestone aquifer is karstic) it is not possible to get a definitive answer from just groundwater levels. Two tracer tests were conducted in 2002 in an attempt to:

- assess the potential for sustained recharge of the Carboniferous Limestone and associated Triassic Marginal Facies aquifers in the vicinity of the Cornelly Quarries;

- determine the regional direction of flow in the Carboniferous Limestone and associated Triassic Marginal Facies aquifers in the Cornelly area; and

- determine the nature of transmission within the Carboniferous Limestone and associated Triassic Marginal Facies aquifers.

Water injected with fluorescent dye was pumped into Stormy Down Swallet north east of Cornelly Quarry, and the abandoned Railway Cutting west of Grove Quarry. The sites were chosen because they both accommodated extended discharge of water at high rates, and would therefore be suitable for the long-term discharge of water pumped from the quarries for dewatering purposes. The full results, discussion and conclusions are available in Appendix M of Appendix 7/1. In summary:

- Tracer injected at the Grove Railway Cutting was only detected at two sampling sites, the Grove Golf Club Borehole 0.25 km from the injection site, and Pyle and Kenfig Golf Club Borehole 1.0 km away to the west. Straight-line groundwater velocities were low, indicating movement via diffuse circulation in fissures and fractures. However, the majority of the tracer injected was not recovered at any of the sampling sites, despite comprehensive on-land coverage.

- Neither of the tracers were recovered in Cornelly Quarry or in adjacent sumps in Stormy Down Quarry, Gaens Quarry or Grove Quarry, indicating that recirculation via diffuse flow in the Carboniferous Limestone was limited. The tracers were also not detected at any other sampling sites, despite a second injection. This confirmed the earlier results of Aldous (1988) at this site. The failure to detect the major part of the tracer injected in both test may be due to technical limitations, including adsorption of the tracer, excessive dilution or photodecomposition (Fluorescein in the case of Stormy Down Swallet). However, it could also be due to long travel times and/or discharge of the conduit systems at other unknown springs, possibly along the coast.

7.4.5 Conceptual model

The conceptual model submitted in support of the first voluntary ES for the Cornelly Quarry ROMP (ESI, 2003b) was developed in an iterative manner in close consultation with the regulators. This conceptual model has now been updated in the light of subsequent further consultations and the large amount of data collected since that time. A draft of the enhanced, comprehensive conceptual model was submitted to NRW for review in October 2013 and was the subject of subsequent meetings in Autumn 2013. A comprehensive, updated conceptual model is presented in Appendix 7/1 and summarised below.

Aquifer System

The Cornelly Group of quarries work Carboniferous Limestone that forms part of a wider, inter-connected aquifer system extending over an area of around 25 km^2 (see Figure 6.1 of Appendix 7/1). This is bounded by the River Kenfig to the north, the River Ogmore to the south, by various faults to the north east and by the coast to the south and west.

The Carboniferous Limestone forms the main, karstic aquifer in this area but is overlain by permeable, layered and possibly karstic, Triassic strata to the west and south. The Blown Sands at Kenfig and Merthyr Mawr form minor aquifers that have a degree of connection with the underlying Carboniferous/Triassic aquifers (described in more detail below).

The main directions of groundwater flow within these aquifers are illustrated on Figure 6.1 of Appendix 7/1. These are derived from a range of evidence described in the preceding sections of this report.

The main discharge point for groundwater in this area (~70%) is to the ~10 km of coastline that forms the western and southern boundaries of the area. As these discharges are effectively immeasurable, this introduces an element of uncertainty in the overall water balance for the catchment. Apart from these coastal discharges, groundwater also emerges:

- At the large springs at New Mill Farm. This groundwater has a strong hydrochemical signature from the Triassic strata.

- Within the Blown Sand dunes at Kenfig and in Kenfig Pool. The hydrochemistry of Kenfig Pool suggests that this water is almost entirely sourced from the Blown Sands, with small amounts of flow from ephemeral springs to the east. Surface water overflow from Kenfig Pool largely re-circulates into the Blown Sands to the west.

- At the large spring at Burrows Well which emerges from the Carboniferous Limestone in the middle of Merthyr Mawr and flows through some dune slacks, eventually soaking back into the sands before reaching the sea.

- Pumping from Cornelly Quarry (and occasionally from Grove and Gaens Quarries). This water is all re-circulated back into the limestone and is therefore not lost to the system.

The following sections describe the conceptual model of some of the key parts of this system in more detail.

Cornelly Group of Quarries

Cornelly is the largest quarry in the group and, as it has been extensively worked and dewatered, it is the one about which the most information is available. The most striking aspect of the groundwater system at Cornelly Quarry is how little abstraction and drawdown effect there is and how stable it has been since detailed monitoring started in ~2001: over a period of ~30 years groundwater levels have been reduced by a total of around 60 m over an area of around 0.5 km^2 and yet the average inflows to the quarry sump are only ~3,500 m^3/d and the off-site pumping rate is only around 2,000 m^3/d - equivalent to a catchment area of less than 1 km^2. Monitoring of groundwater levels in the area confirms that drawdown has extended over a limited area.

The low transmissivity of the aquifer in this area is due to a combination of stratigraphical, structural and erosion/dissolution processes:

- The Cornelly Oolite worked at the quarry is a thickly bedded, oolitic limestone which is likely to be less prone to karstification than units with numerous mudstone horizons;

- The strata within the quarry are generally horizontal with little faulting. The extensive north-south jointing is largely infilled with clayey material;

- This area forms a high plateau with little opportunity for chemically aggressive runoff from adjacent strata which might enhance/reactivate karst;

- The karst re-activation that has occurred is limited to the zone near the natural position of the water table. The current sump elevation is well below this.

The conclusion of the palaeokarst review carried out for this study (Appendix H of Appendix 7/1) was that the present phase of karst development/re-activation extends down about 40 m from the surface. There is little evidence for integration of the dispersed recharge from the unsaturated zone within a substantive karst conduit network. Rather, due to the very high frequency of dilated joints, the dewatered saturated zone appears to be characterised by diffuse fracture flow. Taken together, this suggests that there is a low probability of the further deepening of Cornelly quarry encountering significant zones of enhanced permeability at depth.

Although the karst survey was extended to the adjacent quarries in 2013, the extent of active karst in Gaens and Grove quarries is less clear as these quarries are smaller and have not been worked to such depths. Discussion in Section 0 implies that there may be a higher risk of encountering permeable features at depth in these quarries although, because the quarries are smaller and will not be worked to as great a depth as at Cornelly, the significance of these is expected to be somewhat reduced.

A schematic cross section east-west through Cornelly and Grove quarries and then north westward to Kenfig illustrates some of the points made above and also links this to the groundwater flow systems between the quarries and Kenfig (Figure 6.2 of Appendix 7/1). It can be seen that the groundwater gradients to the west of the Newton Fault are generally flatter than to the east, implying a much lower transmissivity in the latter area.

New Mill Springs

New Mill Springs form an important discharge point for the northern part of the Carboniferous Limestone/Triassic aquifer system. The springs have a strong hydrochemical signal indicating that the groundwater has flowed through the Triassic strata (Appendix L of Appendix 7/1). The total gain in the River Kenfig in this area is consistent with a catchment area of 8.8 km^2 (Appendix J of Appendix 7/1).

Kenfig Pool and Dunes

The groundwater system at Kenfig comprises three aquifers: the Blown Sand dunes, and the underlying glaciofluvial gravels and Carboniferous/Triassic aquifers. Figure 6.3 of Appendix 7/1 shows a schematic east-west cross section of the conceptual model of the area.

The eastern boundary of the saturated Blown Sand has been estimated by Jones, 1993 (see Figure 3.3 of Appendix 7/1). It follows the eastern boundary of Kenfig Pool northwards to the remains of Kenfig castle and south west out to Sker point. Directly beneath the sands a sequence of low permeability estuarine clay deposits extends across the majority of the site from beneath Kenfig Pool to the coast (as confirmed by borehole logs and geophysical surveys). This horizon limits the hydraulic connection between the sands and the underlying aquifers.

Contours by Jones, 1993 based on a very extensive monitoring network of dip tubes, show the presence of a groundwater high north west of Kenfig Pool (Figure 3.3 of Appendix 7/1). The majority of groundwater within the sand aquifer flows westwards, down gradient from this high towards the coast, with a smaller amount of flow north to the River Kenfig and south east to Kenfig Pool. Groundwater level and hydrochemical data imply that recharge from rainfall over the site provides the great majority of flow in the system.

Beneath the estuarine clay, the underlying gravels form a minor, confined aquifer. Groundwater level fluctuations are much larger in the gravels than within the Blown Sands and the hydraulic gradient is downwards except in very wet periods (Figure 5.3 of Appendix 7/1). The latter fact implies that the gravel aquifer discharges towards the coast rather than upwards through the sands. There will be some downwards leakage from the sands to the gravels, however, the contrast in the behaviour of groundwater levels in the Blown Sands and gravels in the immediate vicinity of Kenfig Pool provides a clear indication that these two aquifers are not well connected.

Groundwater levels in the gravels show similar, if subdued, trends compared to boreholes completed in the underlying/adjacent Triassic strata. This may imply a degree of connection between these groundwater systems.

Borehole N is the nearest borehole completed in the Triassic strata to the dunes. It has groundwater levels which are almost always below those in the nearby Kenfig Pool. Groundwater levels in Borehole A (also completed in the Triassic about 300 m to the south west) are also lower than the pool in summer. This implies that this aquifer system discharges towards the coast rather than upwards through the sands. There is a mapped area of Triassic strata on the beach to the west of Kenfig pool and this may be the main discharge point.

Merthyr Mawr

There are two distinct hydrogeological units at Merthyr Mawr – the Blown Sand superficial deposits at surface (within which the dune slacks form) and the underlying Carboniferous Limestone. A degree of hydraulic separation between the two units is provided by a clay layer which appears to be present across the majority of the site and is typically more than 0.5 m thick. Clay may be absent in the west toward the SAC boundary and in what may be a buried channel next to the Ogmore River. A schematic of the conceptual model is shown in Figure 6.4 of Appendix 7/1.

The Blown Sand aquifer is split into two topographic levels with an area at lower elevation, within which the dune slacks form, adjacent to the sea and an area at higher elevation further inland. The elevation step between the two is coincident with a step in the underlying limestone which can be seen cropping out where the Blown Sand thins along this line. North of this, the Blown Sands are considered to be largely dry and the text below focusses on the southern half of the site where the slacks occur.

Although there are no coincidently-located monitoring locations in the limestone and sand, comparison of the closest monitoring locations suggests that limestone water levels are generally below those in the sand. Due to the low storage of the limestone, groundwater levels are significantly more variable than the sands aquifer and therefore there are times when the limestone aquifer water levels are higher than the sand levels and the gradients are reversed (i.e. when Burrows Well discharges).

In the area to the south of Burrows Well, water levels are affected by the discharge of limestone groundwater levels into the Blown sands which causes large areas to pond, possibly on a shallow clay layer in this area (SWS, 2010). When the spring stops flowing, these water levels drop rapidly by three or more metres (e.g. piezometer D7) i.e. the groundwater system in this area is not typical of dune slacks more generally.

There are three main inputs to the groundwater system in the sands: direct recharge, runoff from less permeable catchments to the north east and intermittent flow from the underlying Carboniferous Limestone that discharges at Burrows Well. Flow from this large, ephemeral spring floods several dune slacks to the south before soaking back into the sands. Groundwater in both the sands and limestone is likely to flow southwards towards the sea.

Water Balance

Water balance calculations were originally carried out for and presented in ESI's previous conceptual model report (ESI, 2003b). These have been updated using the results of the flow network model developed for this assessment (Appendix 7/3) and the following conclusions have been drawn:

- The water balance for the Kenfig Blown Sand system shows that almost all of the flow in the Blown Sands is sourced from direct rainfall (2% from surface water inflow). This flow leaves the system by a mixture of groundwater flow and overland flow via the slacks with a very small component of downwards leakage into the underlying sands and gravels.

- All of the water recharging to the Carboniferous Limestone and Triassic marginal facies aquifers in the northern part of the study area can be accounted for, principally via outflows at the New Mill Farm Springs. The good flow balance in this area provides strong support for the conceptual model and is consistent with the observed water levels and hydrochemistry.

- In the coastal lowlands around Porthcawl the water balance is not as good. This is because the main outflows from the aquifer are spread out along 10 km of coast. In places these outflows can be directly observed, but a high proportion appears to be relatively diffuse.

- The water balance for the Merthyr Mawr area implied that Burrows Well provides 45% of the total inflow to the Blown Sand system with the remainder being sourced by direct recharge. The principal outflow is outflow to the sea but around 14% leaks downwards to the underlying limestone.

Discussions with NRW for this phase of work have identified a need to assess transient aspects of dewatering at the Cornelly group of quarries (the rate at which the effects of a sudden increase in abstraction would transmit away from the quarries, the effects and duration of recovery at the end of pumping), and also an incorporation of the variation in hydrogeological conditions at Kenfig and Merthyr Mawr.

In order to do this, it was decided to adapt the groundwater flow network model used for the previous Cornelly ROMP ES to work in transient mode and also to directly simulate conditions at Kenfig and Merthyr Mawr through the incorporation of additional cells (rather than using the supplementary calculations developed previously). The updated model construction and results are described in Appendix 7/3.

7.4.6 Uncertainties

At the start of the current investigation in 2001 a number of key uncertainties were identified which could constrain the ability to predict the potential impacts of deepening the quarries accurately. As discussed in Section 7.2.4, these uncertainties have been reduced as far as possible by a phased approach of investigation (including over 12 years of baseline monitoring) followed by very detailed modelling (Appendix 7/3) and associated sensitivity analysis. This has reduced the level of uncertainty in the assessment to a point at which any residual uncertainties can be appropriately addressed by means of an adaptive management strategy (See Section 7.10 Water Management Plan).

In this section these uncertainties are discussed together with the implications for the impact assessment (i.e. how they have been addressed).

Outflows from the Aquifer

Uncertainty

The most significant uncertainty in the conceptual model is the nature and distribution of conduits in the limestone aquifer. At the start of the present investigation this uncertainty was exacerbated by the fact that the main discharges from the aquifer had not been identified during previous studies.

The current investigation has confirmed that the New Mill Farm Springs are the major discharge point for most of the northern part of the study area. A good water balance has now been constructed for this area (Appendix I of Appendix 7/1) consistent with the substantial volume of monitoring data and with a consequent improvement in confidence in the conceptual model. The tracer tests were not successful in demonstrating the catchment area for these springs, but the combined analysis presented in this study provides some constraints on the possible boundaries of the catchment.

In the coastal lowlands the water balance is still poorly constrained. However an assessment of the total recharge to these areas indicates that the total outflow is consistent with aquifer properties derived by other methods (Appendix G of Appendix 7/1).

Implications for Impact Assessment

The improved water balance for the area has significantly increased confidence in the conceptual model. This should be reflected in increased confidence in the impact assessments. However, sensitivity analysis has been carried out on the effect of changing recharge by the largest range considered credible: +/-15% (with associated variation in aquifer transmissivity) on the predictive simulations.

Conditions at Depth below the Quarries

Uncertainty

At present Grove and Gaens quarries are not being dewatered and Cornelly Quarry requires relatively little pumping to control water levels considering the size of the excavation. The available borehole information and the review of palaeokarst features has clearly indicated that there are unlikely to be active karst features at depth underneath Cornelly Quarry and that quarry dewatering is unlikely to reactivate any of the palaeokarst features present at depth.

The situation at Gaens and Grove Quarries is less clear and there are some grounds for believing that the risk of encountering fissures at depth are greater at these two quarries However, the fact that these quarries are substantially smaller than Cornelly and the depth to which they are proposed to be worked is less, will also reduce this risk.

Implications for Impact Assessment

As discussed in Section 7.2.4, this risk/uncertainty is best managed by means of close scrutiny of pumping rates at each of the sites as envisaged by the revised Water Management Plan (Appendix 7/5).

Connection Between the Limestone Aquifer System and the Dune System at Kenfig

Uncertainty

At the start of this study it had been suggested that up to 30% of the water in Kenfig Pool could be sourced from the limestone aquifer (BGS, 2000).

The evidence presented in this study (e.g. hydrochemistry in Appendix L of Appendix 7/1 and modelling (Appendix 7/3)) clearly demonstrates that the hydrological system in the Blown Sands at Kenfig is almost entirely sourced from direct rainfall rather than the limestone aquifer (there is some minor inflow to Kenfig Pool from the till to the east).

In addition, the main area of humid dune slacks to the west of the pool is underlain by a relatively impermeable layer of estuarine clay which separates the Blown Sands aquifer from the underlying glaciofluvial sand and gravel aquifer.

To the north east of the pool the glaciofluvial sand and gravel appears to act as a ‘drain’, both for a small part of the overlying Blown Sands and the underlying ‘solid geology’ (Carboniferous and Triassic). At this point there is therefore a link, if rather tenuous and indirect between the Blown Sands and limestone aquifer. However, the flow network model (Appendix 7/3) indicates that the Blown Sands aquifer is not a significant discharge point for the Carboniferous Limestone aquifer system.

Implications for Impact Assessment

The lack of a direct link between the Carboniferous Limestone aquifer and the Blown Sands system significantly reduces the risk that dewatering of the quarries could affect the habitat in the dune slacks. However, the impact assessment still considers the potential impact of dewatering on water levels in this area via indirect routes (i.e. the gravels).

Previously the effects of predicted changes of water level in the underlying strata were translated into effects on water levels in the Blown Sands by means of simple, supplementary calculations. There were a number of comments on this approach by the regulators in previous rounds of consultation (ref section 7.2.6) and the approach adopted (Section 7.2.4) has been to develop a fully integrated approach using a transient flow network model. The exact details of the connection between the limestone and the Blown sands at Kenfig has been the focus of detailed consultation between ESI and NRW during autumn 2013.

The need for sensitivity analysis to address the aspects of the model that are not fully constrained by the calibration of the flow network model has been discussed in detail with NRW during autumn 2013 and, where appropriate, these sensitivity runs have also been taken through to the predictive stages.

Connection between the Limestone Aquifer System and the Dune System at Merthyr Mawr

Uncertainty

At the start of the study the hydrogeology of the Blown Sands system at Merthyr Mawr was much less well understood than that at Kenfig.

The data subsequently collected by T.S. Rees in conjuction with Lafarge-Tarmac and the regulators indicate that there is a thin clay layer between the limestone and sand over most of the site, potentially limiting the connections between these formations. Groundwater levels in the Blown Sand are otherwise mostly above those in the underlying limestone. The discharge from Burrows Well spring therefore provides the main inflow from the limestone to the Blown Sands and this has now been monitored for approximately six years.

Implications for Impact Assessment

The improved understanding of the hydrological system at Merthyr Mawr has focussed attention on the area of Carboniferous Limestone to the south of the quarries. The potential for dewatering of the quarries to cause drawdowns in this area and the effect of this on the hydrology of the Blown Sands is addressed in this impact assessment.

Local baseline monitoring also demonstrates that the groundwater levels in the vicinity of the flooded slacks in Merthr Mawr are not typical of other areas of dune slacks in Merthyr Mawr and Kenfig: groundwater levels appear to be perched on a shallow clay layer and drop rapidly by several metres once the spring stops flowing.

Again, as at Kenfig, an integrated approach has been adopted rather than the supplementary calculations previously used. The exact nature of the connection between limestone and Blown sands at Merthyr Mawr has also been subject of detailed discussion between ESI and NRW during autumn 2013. The discharge from Burrows Well is very variable and so a transient approach is required.

The need for sensitivity analysis to address the aspects of the model that are not fully constrained by the calibration of the flow network model has been discussed in detail with NRW and, where appropriate, these sensitivity runs have also been taken through to the predictive stages.

Migration of Leachate from Landfills

Uncertainty

The migration of landfill leachate from the two landfills in the area is potentially indicative of groundwater flow directions (although density effects on the flow of the leachate may mean that this is less indicative of broader groundwater flow patterns). The interception of contaminated groundwater by quarry dewatering would be potentially problematical. A detailed review of hydrochemical data from the study area has clearly identified that some groundwater in the immediate vicinity of the landfills has been contaminated by leachate but that this effect was very local to the landfills. In the case of Stormy West this is in part due to the frequent, north-south orientated, clay filled joints that cross the aquifer in this area.

An area of slightly contaminated groundwater was identified to the north of Gaens Quarry. This is believed to be related to the presence of a farm soakaway in this area.

Implications for Impact Assessment

The potential for migration of landfill leachate towards the quarries will be assessed by means of assessing simulated changes in groundwater flow in the model cells that represent the landfills. The contamination of groundwater to the north of Gaens Quarry has some implications for the potential impacts of dewatering at this site.

Requirements for monitoring the water quality in the quarry sumps are included in the Water Management Plan.

Feasibility of Water Management Options at the Quarries

Uncertainty

An important consideration for the impact assessment will be the feasibility of future water management options for the quarries. Deepening the quarries will involve additional dewatering and the location of the discharge for this pumped water will have an effect on the predicted impacts of the operation of the quarries.

The present preference is for continuation of current practice of the discharge of water into adjacent sumps as this does not involve the loss of water from the aquifer system. The tracer tests carried out as part of this study involved the pumping of large quantities of water to two sink holes. The tracer tests did not fully demonstrate the direction of groundwater flow from these sink holes although this has now been constrained by the results of the flow network model.

Implications for Impact Assessment

The impact assessment will address the remaining uncertainty in the various options for disposal of dewatering water. This is best managed by means of the Water Management Plan (Appendix 7/5) and discussed further in Section 7.10 below.

7.5 Methodology: Approach to Impact Assessment

On the basis of the conceptual model developed for the area, an approach to the impact assessment has been adopted which incorporates a quantitative simulation of groundwater flows within the recommended risk assessment framework.

7.5.1 Impact Assessment Methodology

The standard approach recommended for environmental risk assessment is set out in "Guidelines for Environmental Risk Assessment and Management", DEFRA, 2011. This recommends a source-pathway-receptor methodology. In the context of the impact assessment for Cornelly Quarry these elements may be defined as:

Source: Dewatering associated with further working of Cornelly Quarry.

Pathways: The groundwater flow pathways or hydrogeological linkages identified in the conceptual model.

Receptors: Key water features.

The risk assessment process can be sub-divided into a number of steps as described below.

Step 1: Identification of Receptors. The identification of a risk requires the presence of all three elements in the source-pathway-receptor chain. The source is by definition the quarries at which active dewatering is occurring (specifically, the reduced groundwater levels in the quarries). The first task in the risk assessment process is therefore to identify any relevant receptors. Potential impact receptors include all water features identified during the water features survey (Appendix D of Appendix 7/1). In addition, the Swansea Southern Carboniferous Limestone groundwater (Water Framework Directive) body, which is classified as being of poor status as a result of risks from saline intrusion, water abstraction and flow regulation, diffuse source pollution and terrestrial ecosystems, has been identified as a potential receptor in the Scoping Direction.

Step 2: Identification of Pathways. Having established all potential impact sources and receptors, it is then necessary to identify pathways between the quarry (the source) and each water feature (the potential receptors) (i.e. determine all source-pathway-receptor linkages). In simple terms, the assessment process must establish whether the groundwater level effects of quarry dewatering could potentially affect any of the identified water features. This has been achieved by considering each potential source-pathway-receptor chain in the context of the conceptual model. Hence, where there is believed to be no significant groundwater pathway between the quarry and a given receptor, this receptor can be removed from the impact assessment process (note: where a pathway linkage is unclear, for example due to uncertainty in the conceptual model, the pathway is assumed to exist). In effect, this risk assessment approach serves to filter the list of potential receptors.

The complete list of potential receptors is shown in Appendix 7/2. This list is divided into potentially vulnerable receptors (i.e. those receptors which are hydrogeologically connected to Cornelly Quarry) and insignificant receptors (i.e. those receptors for which there is no pathway to the quarry). A brief justification for all receptors considered to be insignificant is also given in Appendix 7/2, along with a figure showing the location of all potentially significant and insignificant receptors. In summary, in addition to the Kenfig SAC (Kenfig Pool and Dunes and Merthyr Mawr SSSIs and associated water features), a total of 24 potentially vulnerable receptors (or groups of receptors) have been identified.

Note that, in this process the Cefn Cribwr SAC referred to in the Scoping Direction was not considered to be dependent on the groundwater systems affected by dewatering at the Cornelly Group of quarries (See Section 2.4.2 of Appendix 7/1 for details) and has therefore not been taken forward as a potentially vulnerable receptor.

Step 3: Quantification of Effects. The presence of a hydrogeological pathway between the quarry and a receptor does not on its own indicate that an effect will occur at the receptor. The next step in the impact assessment process must therefore be to address whether or not there is likely to be a hydrological/hydrogeological effect at each potentially vulnerable receptor resulting from quarry development (and decommissioning) works. This requires a degree of quantification. Since the majority of impacts relate to water level changes, it is therefore necessary to quantify the degree of groundwater level change at each potentially vulnerable receptor, or alternatively the change in water balance components (i.e. groundwater inflows and outflows) surrounding that receptor. This was achieved by means of using the calibrated flow network model in predictive mode (Appendix 7/3).

Step 4: Assessment of Significance. The demonstration and quantification of a potential effect does not in itself represent a potential impact. This requires an assessment of the significance of the effect. There are two aspects to the assessment of significance:

1. it is necessary to compare the size of the potential effect with a relevant criterion. If the size of effect is smaller than the criterion then the effect does not represent a significant impact.

2. if the size of effect is potentially greater than the relevant criterion, it is necessary to assess the significance that the potential impact represents. The significance of an impact is dependent on the magnitude of the effect and the importance of the receptor.

<u>1. Relevant Criteria</u>

Step 4 (Section 7.5.1) requires a measure of impact significance (i.e. when does a predicted effect become a potentially significant impact?).

The simulated effects on flows and water levels in the SAC have been carried forward to Chapter 8.0 where their potential significance is discussed in the context of their ecological status. The text in this section therefore simply presents the timing and magnitude of these effects in hydrogeological terms, without comment on indirect ecological effects.

However, the detailed time series statistics discussed in Appendix D of the Water Level Management Plan (Appendix 7/5) shows that, within the Blown Sand aquifers at Kenfig and Merthyr Mawr, sustained changes in water level of 0.1 m or less would be very difficult to detect even after several years i.e. changes smaller than 0.1 m would effectively be below the resolution of current technology (by which we mean the combination of monitoring data and the simulation of expected levels).

In this section, the impact significance at each receptor site has been evaluated separately on the basis of the conceptual understanding of the local groundwater system. To assist in this evaluation, the following interim, conservative guidelines (based on those agreed with NRW in the WMP (Appendix 7/5)) have been adopted for screening purposes:

- For the Blown Sand aquifers at the Kenfig and Merthyr Mawr SACs a predicted groundwater level reduction of 0.1 m has been adopted. This is at the lower limit of what would be detectable through statistical analysis of long-term groundwater levels. There are no receptors at this location other than ecological ones and therefore this limit is used as an initial screening threshold for the purposes of this section.

- For licensed groundwater abstraction boreholes a predicted groundwater level reduction in excess of 0.5 m is taken to indicate a potentially significant impact which will require further assessment (i.e. evaluation of borehole construction details, pump intake level etc.).

- For shallow wells, a predicted groundwater level reduction in excess of 0.25 m is taken to indicate a potentially significant impact which will require further assessment.

- For ponds (excluding Kenfig Pool and any dune slacks in Kenfig Pool and Dunes and Merthyr Mawr SAC), a predicted groundwater level reduction in excess of 0.1 m is taken to indicate a potentially significant impact which will require further assessment.

- For spring flows, a derogation of flow in excess of 10% of mean long term flows is taken to indicate a potentially significant impact which will require further assessment.

With regard to water quality, the effects of quarry development should not induce additional landfill leachate or saline intrusion to the extent that key drinking water quality standards (i.e. ammonia and EC) are likely to be compromised. In practise a semi-quantitative, expert judgement-based approach has been taken to determine the degree of effect and the consequent impact significance rather than comparison against specific guideline values for individual contaminants or groups of contaminants.

Where an effect falls below the threshold criteria described above, it is taken to be negligible (apart from simulated changes at the SACs where all changes are taken through for consideration in Section 8). Where it exceeds the critical threshold, a site specific assessment of the degree of effect (low, medium, or high) is applied based on the particular conditions at that receptor (e.g. large natural variation in groundwater levels compared to the predicted change).

2. Importance of Receptors

The second factor in the consideration of degree of impact is the importance of the receptor. Receptors have been assigned to one of three status categories – low, medium or high. The methodology for assigning to a particular category is based on the following general criteria although it is subjective to a large degree:

- Low Status – Unlikely to be of significant ecological or societal value (e.g. small ephemeral pond); surface water and groundwater abstractions that supply or impact on an individual or small number of people (e.g. farm or home supply);

- Medium Status – Of local ecological or societal value or supporting medium or high status ecological features (e.g. springs); surface water or groundwater abstractions that supply or impact on a local community (e.g. local water supply or water supply to a local amenity);

- High Status – Nationally and internationally designated ecological sites (e.g. SACs) or features supporting these (e.g. springs); surface or groundwater abstractions that feed into public water supply.

Degree of impact is determined by applying the degree of effect with the receptor status according to the matrix in Table 7-10 below:

Table 7-10 Impact Assessment Matrix

		Receptor Value		
		Low	**Medium**	**High**
Degree of effect	**Negligible**	Negligible	Negligible	Negligible
	Low	Minor	Minor	Moderate
	Medium	Minor	Moderate	Major
	High	Moderate	Major	Major

Only adverse impacts that are Moderate or higher (highlighted with red text in the table above) are considered to be potentially significant and in need of mitigation.

Note that the hydrological / hydrogeological impacts at Kenfig / Merthyr Mawr relate to changes in water levels, and the terminology used to characterise the impacts are not to be equated with other indirect impacts. The nature of any indirect ecological effects are considered separately in Chapter 6.0 of the ES.

Categories for Reporting Effect/Impact

A short list of potential impacts associated with quarrying activities is presented in Table 7-10. In order to present the results of the assessment in a clear and concise manner, these have been combined with the list of potential hydrological/hydrogeological impacts identified in the Scoping Direction (Section 7.2.1) to produce the following four categories:

A. General effects on groundwater levels and flows – this is taken to include the assessment of the potential impacts on the water resources of the Swansea Southern Carboniferous Limestone groundwater (Water Framework Directive) body;

B. Potential effects on water levels at Kenfig/Cynffig SAC/SSSIs;

C. Potential effects on water levels and flows at other potentially vulnerable receptors; and

D. Other potential effects (water quality and settlement) – this is taken to include the assessment of the potential impacts on the water quality of the Swansea Southern Carboniferous Limestone groundwater (Water Framework Directive) body.

Table 7-11 Short List of Potential Impacts

Phase of Development	Activity	Potential Impact	Impact Category	Impact Duration[1]
Quarrying Phase	Dewatering	Change of current groundwater flow regime	A	T
		Reduction in stream baseflow contribution	C	T
		Disturbance of contaminated groundwater (aggravation of leachate migration)	D	T
		Ground instability associated with dewatering extent	D	P
		Reduction in spring flows	C	T
		Reduction in pond or pool levels	C	T
		Drying of dune slacks	B	T
		Reduction in borehole performance / yield	C	T
		Induced saline intrusion	D	(P)
	Quarry working	Groundwater pollution from accidental fuel spills, leaks etc.	D	T
		Surface water pollution from contaminated run off	D	T
	Disposal of dewatering water	Change of current groundwater flow regime (change in infiltration / recharge)	A	T
		Change of stream baseflow contribution	C	T
		Change of spring flows	C	T
		Change of pond or pool levels	C	T
		Change to groundwater quality	D	T
		Increased surface water turbidity	D	T
Decommissioning Phase	Creation of permanent quarry lake (cessation of dewatering)	Change of current groundwater flow regime	A	P
		Change of stream baseflow contribution	C	P
		Change of spring flows	C	P
		Change of borehole performance / yield	C	P
		Change of pond or pool levels	C	P

1 Temporary (T) or Permanent (P)

7.5.2 Groundwater Flow Simulation

Groundwater Flow Network Model

A groundwater flow network model (constructed in MS Excel) has been developed to assist in the prediction of groundwater level impacts. The output/conclusions are included at Appendix X This tool predicts the spatial distribution of groundwater level changes resulting from quarry dewatering by dividing the area up into a number of cells and performing linked water balance and groundwater flow calculations between each cell.

The model used in this assessment is based on the steady state model used in the previous assessment (ESI, 2004) which was subject to detailed review by the EA for Wales at that time. In response to the increased amount of baseline data collected since that time and the improved understanding of the conceptual model, the steady state model has been refined and converted into a transient model. This allows a better understanding of the potential impacts on sensitive receptors to be achieved. The way in which this refinement and conversion has been carried out has been discussed in detail with NRW at several meetings in the second half of 2013 (Section 7.2.6).

The flow linkages within the model were set up to include all potentially significant source-pathway-receptor chains as identified by the risk assessment work described above. Full details of the flow network model are presented in Appendix 7/3.

The model has been calibrated to current conditions (observed flows and groundwater levels) and then used to predict the effects of changing the way in which each of the quarries is dewatered (including decommissioning). The success of the model in predicting current conditions provides a measure of confidence in its accuracy.

Sensitivity analysis has been used to assess the level of uncertainty associated with each aspect of the model calibration. Where this uncertainty is potentially significant, sensitivity runs have been carried forward into the predictive phase.

Assessment of Current Effects of Cornelly Quarry

Monitoring of groundwater levels in the vicinity of Cornelly Quarry over the last 20 years has shown that, whilst there has clearly been some local effects of lowering the quarry floor to ~60 m below rest water levels (and associated off site pumping), this has been confined to the immediate vicinity of the quarry. No effects have been detected at a greater distance (e.g. at South Cornelly Borehole, ~1 km west of the quarries) and clearly not at the Blown Sands (see discussion on water levels in Appendix K of Appendix 7/1 and Climate Based Assessment Criteria in Appendix C of the Water Management Plan (Appendix 7/5)).

The flow network model provides a tool that allows the theoretical effects of the current quarrying activities to be assessed as described in Appendices 7.3 and 7.4. This confirms that any theoretical effects on water levels and flows at the SAC are very small and are below the likely level of physical detection.

Model Scenarios

The flow network model has been used to predict the effects on groundwater flows and cell water balance components at a number of key development stages of the quarries (i.e. 15 year (end of current ROMP cycle) and 42 year/full development). Descriptions of all model prediction runs, including those relating to the development of Cornelly Quarry in isolation and the simultaneous development of Cornelly, Grove and Gaens quarries, are outlined in Table A7.4a (Appendix 7/4). These can be summarised as follows:

- Baseline run – Current conditions carried forward over the prediction periods for comparison;
- Individual development runs – 15 and 42 year scenario for Gaens only (GA15 and GA42 – pumping to the sinkholes to the north). This run also maintains the current pumping from Cornelly (discharge to Pant Mawr);
- Combined development runs - 15 and 42 year scenario for all quarries combined (ALL15 and ALL42, Cornelly pumping to Pant Mawr, Grove to railway cutting, Gaens to sump in north of quarry);
- Sensitivity runs – nine runs based on ALL15 with key parameters altered within uncertainty limits (SENS1 to SENS9)
- Recovery runs – Cessation of pumping at the end of the ALL42 scenario with various combinations of quarries ceasing and residual pumping rates (RECOVERY, RECOVERYGAENS, RECOVERYPUMPING5, RECOVERYPUMPING6).

The model is a transient model and, therefore allows prediction of the time that water levels will take to reach the equilibrium position at each of these development stages. In general water level changes are expressed as differences with respect to the current conditions (i.e. the baseline run); however, it should be noted that current conditions may not reflect pre-quarrying conditions as some quarry development and dewatering has already taken place, although monitoring to date has been unable to discern any effects of the quarrying outside the immediate vicinity of the quarry

The climate sequence for the predictive scenarios has been constructed by repeating the climate sequence for the historic, calibration, model run (1992 to 2013) twice. This gives a long sequence with several extreme wet/dry events which allows the sensitivity of the conclusions to variations in rainfall to be assessed.

Note that the results presented are for changes at the cell node (as shown on Figure A7.2a in Appendix 7/2): no interpolation has been applied to assess the variation in changes within an individual cell. The cell sizes are generally such that this should not significantly affect the conclusions at individual receptors. However, some of the cells (e.g. that at Porthcawl) are quite large and impacts at some of the more distant receptors in this area may be slightly overstated by this approach.

Consideration of Uncertainties (Sensitivity Analysis)

Although the previous phases of investigation have succeeded in clarifying many aspects of the conceptual understanding of the 'Cornelly' system, there remains a level of uncertainty regarding certain aquifer properties and groundwater flow processes. In order to account for this inherent uncertainty in the prediction of groundwater behaviour within a fissured limestone system, all predictions of groundwater level change must be considered in the context of a potential margin of error.

The extent of these potential error margins has been defined using model sensitivity analysis and also by testing the effect of modifications to the conceptual model on the model predictions (see Appendix 7/3). These modifications were designed in consultation with technical staff from the regulators starting during 2003 including detailed discussions with NRW in 2013, particularly consideration of the connection between the Blown Sands at Kenfig and Merthyr Mawr and consideration of 'highly permeable features' as discussed in the following section..

Consideration of the possible effects of interception during quarrying of a 'highly permeable feature'

As discussed in Section 7.4.4, a detailed review of the local palaeokarst by an appropriate expert has found that there is a very low possibility of encountering a highly permeable feature at depth in Cornelly Quarry. At Gaens and Grove Quarries the risk of encountering such a feature is less well constrained due to the fact that the quarries are not currently dewatering.

It is proposed to manage this very low possibility risk by means of the revised Water Management Plan (Appendix 7/5). However, some of the approach and results of the modelling assessment are of relevance to the management of this risk:

1. The predictive development scenarios apply the full change in water level in the quarries instantaneously. This is a conservative assessment as, in reality, the quarries would be deepened over a number of years. However, the resultant simulated change in water levels at the more distant receptors (e.g. Kenfig and Merthyr Mawr) provides a useful indication of the timescales over which the effect of intercepting a highly permeable feature in the quarries would develop. This is discussed in the relevant sections below.
2. A predictive sensitivity run has been run with recharge increased throughout the model by 15% (this is the largest change in recharge relative to the best estimate that is considered to be credible). To ensure that groundwater heads are maintained at their approximate calibration position, the transmissivity was also increased by 15% throughout the model. This therefore provides a predictive run with the highest transmissivity that is consistent with the current conceptual model.

7.5.3 Assessing Other Impacts

It is recognised that not all impacts of quarrying relate solely to changes in groundwater level. It is also necessary to consider potential impacts on surface and groundwater water quality, ground stability and the freshwater-saline interface (i.e. saline intrusion impacts).

The assessment of these additional impact categories has been performed either by qualitatively (or, if appropriate, quantitatively) considering their impact in the light of the groundwater level or flow predictions, or through the application of previous experience and expert knowledge (e.g. saline intrusion impacts may be assessed by predicting groundwater level changes along the coastal margin in the context of both specific coastal hydrogeological conditions and expert knowledge of freshwater-saline interface processes).

7.6 Predicted Impacts of Future Quarry Development at Gaens

In this section, the effects predicted by the model run involving further development of Gaens Quarry on its own is discussed (GA15, GA42). In Section 7.7, the predicted effects of the combined operation of all three quarries are discussed, whilst in Section 7.8 the predicted effects of quarry decommissioning are discussed. The potential significance of these predicted effects on the SAC receptors is discussed in Section 8 and for other receptors is discussed in each section below.

The predicted effects of both the development of Gaens alone (i.e. model runs GA15 and GA42)) and the combined development of Cornelly, Grove and Gaens (ALL15 and ALL42) are summarised in Tables A7.4a to A7.4e in Appendix 7/4:

- Table A7.4b presents the simulated change in groundwater levels relative to baseline for each prediction run at the model cell nodal points.

- Table A7.4c shows the simulated change along certain critical flow paths relative to baseline conditions, such as the groundwater inflow to the model cell representing the sand and gravel aquifer at Kenfig.

The assessment of the potential impacts relating to the development and decommissioning of Gaens Quarry is presented in Table 7-12 and Table 7-13 respectively. Where appropriate, comments relating to the combined development of all three quarries are incorporated into Table 7-13 (note: the decommissioning condition for the combined quarries scenario is assumed to represent a worse case compared to decommissioning of Gaens alone).

Both tables combine the list of potentially sensitive receptors (see Appendix 7/2) with the listing of potential impacts as shown in Table 7-10. The result is a list of all potential impacts (from either quarry development or decommissioning) which may arise at each of the identified receptor sites.

Each of the identified potential impacts is assessed in the context of:

- predicted water level changes.
- predicted changes to groundwater flows.
- expert knowledge of the local groundwater system (i.e. the conceptual understanding of the system) and the nature of specific receptors (as derived from the detailed water features survey).

Details of the criteria used to assess each impact are indicated on Table 7-12 and Table 7-13 under the ‘Assessment Criteria’ column. Comments regarding the impact assessment itself are presented in the ‘Impact Assessment’ column. The remaining columns provide an indication of whether or not the impacts are considered to be potentially significant in hydrological / hydrogeological terms (based on the comparison of predicted water level or ground water flow changes and appropriate impact thresholds).

Note that the hydrological / hydrogeological effects at Kenfig / Merthyr Mawr relate to changes in flows and water levels, and the terminology used to characterise these effects are not to be equated with indirect ecological impact to habitats within these areas (the SAC). The nature of any indirect effects is considered separately in Chapter 6.0 of the ES.

All potentially significant impacts on Table 7-12 and Table 7-13 are highlighted in one of two colours, indicating the stage of development at which the impact becomes significant (i.e. after 15 years or at full development). A separate colour scheme is used to highlight potential impacts which are different for the combined quarry scenarios.

Further discussion of the potentially significant impacts which are highlighted on Table 7-12 and Table 7-13 are provided in the relevant effects sections.

7.6.1 A: General effects on groundwater levels and flows (Gaens only)

Groundwater Levels

In general, the effects of the planned development of Gaens Quarry on groundwater levels in the surrounding area are small. For consistency, the effect on mean water levels over the last five years of the future simulation has been discussed below (i.e. after full equilibration). However, the full simulated hydrographs are presented in Appendix 7/4 and any potentially significant short term effects are raised in the text below.

At full scale development of Gaens the largest predicted drawdowns in five year mean levels are in the immediate vicinity of the quarry and in the area to the south, however the discharge of dewatering water from Cornelly Quarry to Grove Quarry acts as a buffer. Beyond this immediate area, predicted five year mean drawdowns are less than 1.3 m at all potentially vulnerable receptors. To the north of Gaens, groundwater levels are predicted to rise due to the discharge of dewatering water to the sink holes in the north with five year mean levels increasing by not more than 2.8 m at all potentially vulnerable receptors.

Groundwater level changes are not established instantaneously. In areas close to the quarry they can occur rapidly but in more distant locations they can take up to 10 years or more to be felt fully.

When the difference between each sensitivity run (SENS1 to SENS9) and its equivalent baseline is compared with the difference between the relevant best estimate end of ROMP cycle run (ALL15) and its baseline run the differences are similar which indicates that the modification of key model parameters within a plausible range does not significantly change the conclusions of this assessment. The range in differences observed in individual sensitivity provides a confidence range on the drawdown predictions for all model runs.

<u>Quarry Dewatering</u>

The model simulates that average off-site pumping rates at Gaens Quarry will be around:

2443 m^3/d at 15 years (0 mAOD).

2352 m^3/d at 42 years (-20mAOD).

These rates are off-site rates and do not take into account recirculation that can occur where the disposal is close to the quarry sump. The occurrence of recirculation would have minimal impact on the flows within the aquifer outside the sump and disposal area but would result in a higher pumping rate from the sump itself.

This is a long term average value. The actual rate in any one month will depend strongly on the amount of rainfall and the way in which the quarry is being worked at that time. Dewatering records at Cornelly Quarry indicate that weekly average pumping rates may vary by +/-50% from the average. Furthermore, the accuracy of pumping rate predictions at Gaens are more uncertain than those derived for Cornelly due to the lack of historic data and less certainty about hydrogeological conditions at depth.

Groundwater Flows

In general, groundwater flows in the limestone tend to increase in the quarry development scenarios: more water is being pumped round the system, creating steeper hydraulic gradients and hence more groundwater flow. These effects are largest in the immediate vicinity of the quarries and are strongly affected by the pattern of dewatering disposals in each scenario.

Away from the quarries the changes in groundwater flow between cells are predicted to be much smaller (generally in the order of a few per cent even for the full scale development scenario).

The sensitivity runs show that there is some difference in the change in mean flows when the sensitivity run and its baseline are compared with the best estimate run (ALL15) and its baseline. Some flowpaths appear to be relatively sensitive (show greater than 10% difference) including:

- Kenfig glaciofluvial deposits
- Kenfig seep
- Kenfig Pool
- Cornelly, Grove, and Gaens inflows
- Flow to Afon Fach/Railway Springs
- Flow from Stormy West to Stormy Down
- Flow toward Tythegston Landfill
- New Mill Farm Springs (and nearby groundwater abstractions)
- Porthcawl coastal discharge

Consideration of the effects of these changes of flow on simulated water levels at key receptors is discussed in the relevant sections (Kenfig and Merthyr Mawr in Section 7.6.2 and other receptors in Section 7.6.3).

Review of the sensitivity runs suggests that these effects on flow are not significantly affected by any uncertainties in model parameterisation. The wider implications of the model sensitivity results are discussed further below.

<u>Swansea Southern Carboniferous Limestone groundwater (Water Framework Directive) body</u>

The simulated changes in groundwater level and flow are considered to have a **Negligible** impact on the quantitative status of the Swansea Southern Carboniferous Limestone groundwater (Water Framework Directive) body.

7.6.2 B: Potential effects on water levels in the dune sands at Kenfig SAC / Kenfig Pool and Dunes SSSI and the Merthyr Mawr SSSI (Gaens only)

As noted above, the predicted effect of the future development of Gaens Quarry with the associated disposal of the water to the north, is to raise water levels to the north and to lower them to the south of the quarry. The results of the GA42 run are discussed below.

Kenfig

When compared with the baseline run, the net result in the Blown Sand aquifer at the Kenfig SAC is a decrease in simulated five year mean water levels of not more than 5 mm and maximum change in water levels during the entire run period of 6 mm. These very small theoretical effects are far below the level of resolution of current detection methodologies (typically 0.1 m).

This can be clearly seen on Figure 8.1 which shows the simulated water levels in the Blown Sand to the west of Kenfig Pool the Baseline and GA42 runs which are effectively indistinguishable although the difference line shows a small theoretical fall in level. This is the area with the largest simulated change in level: simulated changes in the Blown Sand to the north and north west of Kenfig pool are much smaller and take around ten years to manifest themselves.

The changes in flow along various flow paths between the quarries and Kenfig dunes discussed in Section 7.6.1 therefore do not appear to have a significant effect on water levels in the Blown Sand aquifer. This is because, whilst these changes in flow are proportionally large, flow (and thus water levels) in the Blown Sand aquifer is dominated by local recharge.

Careful review of the difference line implies that a sudden change in water level e.g. a theoretical encountering of a highly permeable feature (or by implication pumping rate) at Gaens Quarry would take 5-10 years to fully manifest itself as a change in water level in the Blown Sand aquifer at Kenfig.

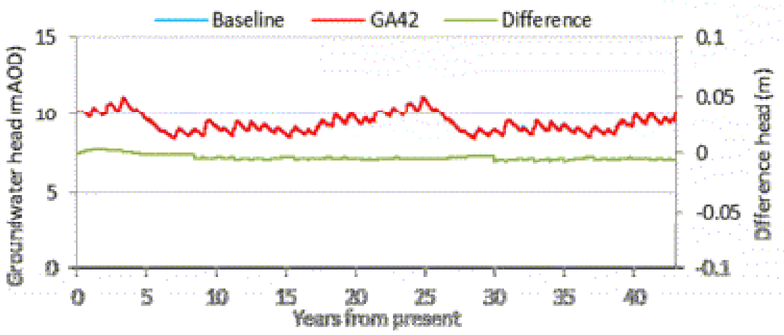


Figure 7-7-1 Groundwater levels and difference at Kenfig – Run GA42 (Model Cell 55 – West of Kenfig Pool)

Baseline (blue) and development run (red), difference (green) is development run minus baseline (positive means a rise in water level). NB Baseline not visible as it is so similar to development run.

Merthyr Mawr

The effects of future quarry development on Merthyr Mawr are assessed by two measures:

1. For the dune slacks to the east and west of the SAC (model cells 44 and 45), the direct model simulation of water levels is used.
2. For the cells representing the Burrows Well and overflow slacks system, the simulated flow at Burrows Well is used. This is because the water levels in this area are not typical of other dune slacks and are entirely maintained by spring flow: when the spring stops flowing each year, water levels rapidly drop by at least 3 m.

In the Blown Sand Merthyr Mawr SAC there is a simulated decline in five year mean water levels of not more than 2 mm and a maximum decline during the full run period of 3 mm. This compares with inter-annual variations which are of the order of metres

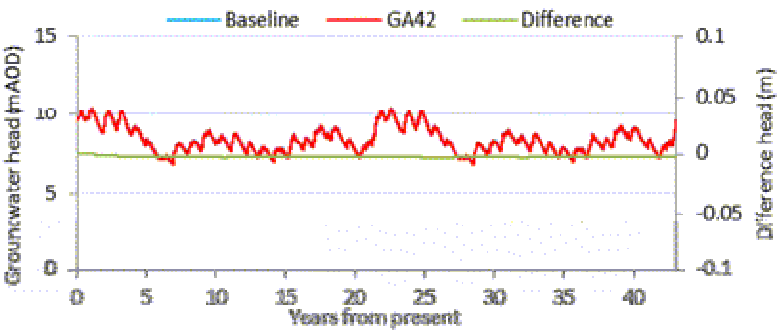


Figure 7-7-2 Groundwater levels and difference at Merthyr Mawr – Run GA42 (Model Cell 45)

Baseline (blue) and development run (red), difference (green) is development run minus baseline (positive means a rise in water level). NB Baseline not visible as it is so similar to development run.

Likewise, changes in flow at Burrows Well in the case of Merthyr Mawr are small (Figure 7-3). The maximum difference is not more than 8 m^3/d decrease (positive difference indicates decrease in flow with respect to baseline). Differences throughout the run are always less than 0.9% and typically less than 0.5% (Figure 7.4).

Careful review of the difference line implies that a sudden change in water level (or by implication pumping rate) at Gaens Quarry would take up to 10 years to fully manifest itself as a change in flow at Burrows Well.

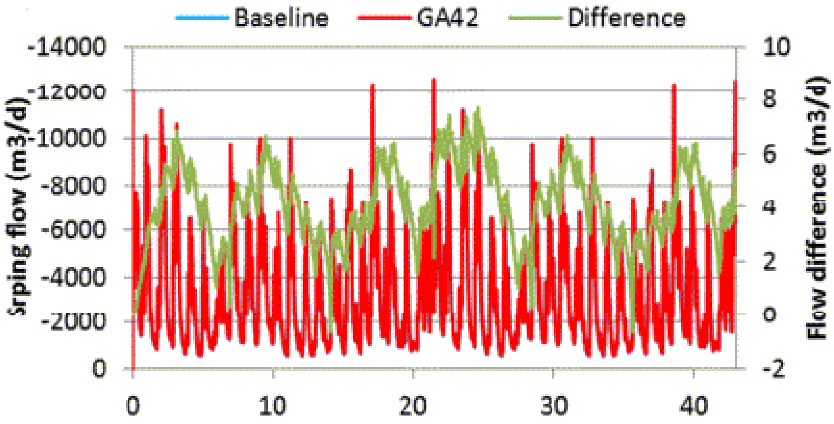


Figure 7-7-3 Flows at Burrows Well – Run GA42

Baseline (blue) and development run (red), difference (green) is development run minus baseline (positive means a decrease in flow). NB Baseline not visible as it is so similar to development run.

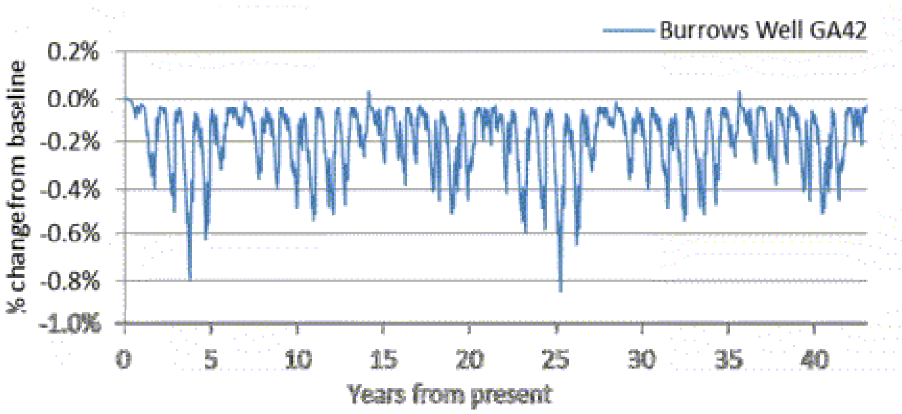


Figure 7-4 Changes in Burrows Well flow (as % change from baseline) – Run GA42

Summary

The impact of development of Gaens quarry alone on the Blown Sand aquifers at Kenfig and Merthyr Mawr is therefore judged to be **Negligible in hydrogeological terms**.

As noted above, the potential indirect effects on habitats within the Kenfig SAC are considered in Chapter 6.0 of the ES.

7.6.3 C: Potential effects and impacts on water levels and flows at other receptors (Gaens only)

In general, the predicted effects on water levels at most of the other potentially vulnerable receptors are less than the adopted criterion for change in water level. Receptors at which slightly larger, potentially significant changes in water level occur are listed below (see Figure A7.2a for locations):

Grove Golf Club (Loc. 40): This borehole is predicted to show a drawdown of five year mean water levels of up to -1.25 m and thereby exceed the critical change of 0.5m (Section 7.5.1 , Appendix 7/5) in 15 year, and 42 year scenarios. Simulated natural variation in levels at this location is less than 20 m, so this represents a noteworthy change.

The full effects of dewatering at Gaens at this location are slightly mitigated by pumping from Cornelly Quarry to Grove Quarry.

Wilderness pond (Loc. 20): This pond is predicted to show a drawdown of five year mean water levels of up to -0.20 m and thereby exceed the critical change of 0.1 m (Section 7.5.1 , Appendix 7/5) in 15 year and 42 year scenarios. The simulated natural variation of 11 m simulated here is not experienced by the pond. This receptor is located close to the coast in a large model cell and so the variation and effect seen here is likely to be less.

Pwll y Waun (Loc. 23): The situation here is the same as Wilderness Pond (Section 7.5.1 , Appendix 7/5).

In general, the predicted effects on groundwater flows in cells which represent selected receptors are also small:

- Five year mean flows at New Mill Farm Springs (which should be taken to also include the potential effects on groundwater abstractions in this area) are predicted to show a 3.5% increase.
- Five year mean net groundwater flows into Afon Fach/Railway Springs/Stormy Down Spring are predicted to increase by a maximum of around 8.1%.

The effect of development of Grove quarry alone on water levels or flow at Grove Golf Club is **Moderate**, at Wilderness and the Pwll y Waun it is judged to be **Minor adverse** and at all other receptors it is **Negligible**.

7.6.4 D: Other potential impacts (Gaens only)

Leachate Migration

The detailed review of the available hydrochemical data (Appendix L of Appendix 7/1) concluded that, whilst the two landfills at Stormy West and Tythegston had contaminated groundwater in their immediate vicinity, this had not extended any significant distance. This is despite the fact that, at present, the hydraulic gradient is already from the landfills towards Cornelly Quarry (by which we mean that groundwater levels in the quarry are lower than those at the landfills). In addition, the strength of the leachate at the sites is likely to attenuate through time.

It would thus appear unlikely that further quarry dewatering will create a significant risk of inducing contaminated groundwater into the quarry sump. The implications of the predicted groundwater flow changes in the immediate vicinity of the landfills, resulting from the development of Gaens Quarry, is discussed in more detail below.

Stormy West: Simulated five year mean groundwater outflows from Stormy West to Stormy Down increase by around 2% due to development of Gaens Quarry whilst five year mean flows from Stormy Down to Cornelly increase by around 0.8%. This reflects an increase in hydraulic gradient between the landfills and the quarries.

Tythegston Landfill: Flows at Tythegston are predicted to be away from Gaens Quarry. The five year mean flow to Tythegston during Gaens development experiences a 0.3% decrease from baseline conditions. This change is not large enough to make a notable difference in the risk of creating enhanced leachate migration and flow remains away from the quarry.

Gaens Quarry: An area of contaminated groundwater was identified to the north west of Gaens Quarry. The origin of this contaminated groundwater is not clear but it may be related to a local farm soakaway. Given the limited effect of the much larger sources of contamination (i.e. Stormy West and Tythegston Landfills) on the groundwater quality across the aquifer, it seems unlikely that there will be any significant, widespread impact from such a localised source of contamination.

Contingency measures to deal with scenarios such as the quarry intercepting a significant amount of landfill leachate are discussed in the Water Management Plan (Appendix 7/5).

Quarry Operations

There is a potential risk to groundwater quality from routine quarrying activities at Gaens Quarry. This risk essentially relates to the accidental release of pollutants which may enter the local groundwater system either through the quarry base or via water discharged off site. The likelihood of any pollution occurring can be reduced through sound operational practices including suitable pollution control measures. Such measures have been proposed in the draft planning conditions submitted with the ROMP application, and given the assumption that the measures will continue to be effectively implemented, they are not considered further in this impact assessment.

Ground Stability

In this impact assessment of Gaens Quarry only it has been assumed that it is feasible to continue to discharge any water required to dewater Gaens quarry into the sink holes to the north west. It is not anticipated that this discharge will cause any localised concentration of groundwater flow that could cause washout and hence localised effects on ground stability.

Saline Intrusion

Discharges of groundwater to the coast are only affected in scenarios in which the amount of discharge at New Mill Farm Springs (the other discharge from the system) is simulated to change. In general the simulated changes in coastal discharge are very small (less than 2.5% change in five year mean flow along any of the critical flowpaths) in all scenarios (see Table A7.4d). This compares with seasonal variation in coastal outflows under baseline conditions which is which is between approximately 60% higher and 40% lower than the mean.

As a result, it is considered that there is no significant risk that the proposed developments will cause saline intrusion. This is consistent with the fact that the proposed quarry developments only involve moving water from one part of the groundwater system to another rather than removing it to a different system.

Swansea Southern Carboniferous Limestone groundwater (Water Framework Directive) body

The simulated changes in groundwater level and flow are considered to have a **Negligible** impact on the groundwater quality status of the Swansea Southern Carboniferous Limestone groundwater (Water Framework Directive) body.

7.6.5 Uncertainty and Risk

Model Sensitivity Analysis

As discussed previously (Section 7.5.2), there is a degree of uncertainty in the model predictions and therefore the impact assessment results. This derives from inherent uncertainties in the underlying conceptual model of the hydrogeological system (as discussed in Section 7.4.4) and also from the effect of model equivalence (different combinations of model parameter can generate similar model calibrations but potentially different model predictions).

In order to address these uncertainties, sensitivity analysis has been used to define the likely error margin for all model predictions (see Section 7.5.2 for approach). The results from the sensitivity analysis (presented in Tables A7.4a and A7.4e in Appendix 7/4) indicate that the error margins for both groundwater level and groundwater flow predictions are relatively modest, especially at the most critical receptors. Hence, for Kenfig, the sensitivity results show a maximum variation of 1 cm from the difference seen in the equivalent prediction run (15 year combined development). At Merthyr Mawr, the sensitivity results show an equivalent maximum difference of 1.5 cm. These are small absolute differences and do not change the conclusions of this assessment. This provides strong support for the robustness of all model predictions.

Possibility of interception during quarrying of a 'highly permeable feature'

As discussed in Section 7.5.2, the model predictive simulations provide useful context for assessing this risk:

1. Timescale for sudden changes at the quarry to manifest themselves at the key receptors. The instantaneous application of drawdowns at Gaens Quarry takes of the order of 5-10 years to fully manifest itself at Kenfig (Figure 7.5) and around 5 years to manifest itself in the Blown Sand at Merthyr Mawr . Note the exaggerated scale on the secondary y-axis. This provides confidence that there would be time to implement the measures described in the revised Water Management Plan (Appendix 7/5) should such a feature be encountered.

2. Sensitivity analysis. In sensitivity run SENS8 the transmissivity is increased across the whole aquifer system by 15%, the highest amount consistent with the conceptual model, and yet comparison of the results of this predictive scenario with the base case shows that the simulated effects at Kenfig and Merthyr Mawr are not significantly different (variation of 1 cm from the difference seen in the equivalent prediction run at Kenfig and 1 mm at Merthyr Mawr).

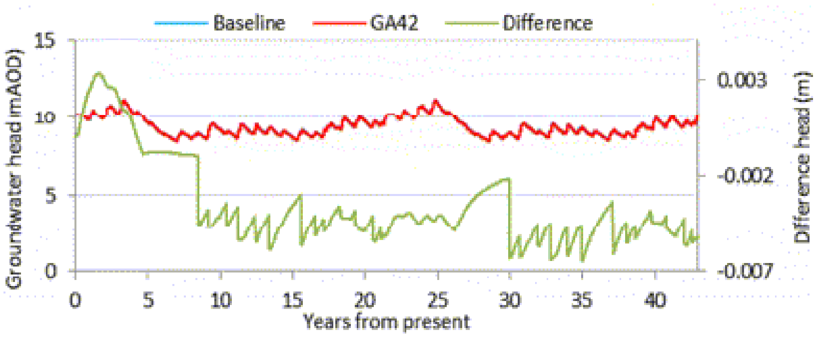


Figure 7-7-5 Groundwater levels and difference at Kenfig – Run GA42 (Model Cell 55)

Baseline (blue) and development run (red), difference (green) is development run minus baseline (positive means a rise in water level). NB Baseline not visible as it is so similar to development run.

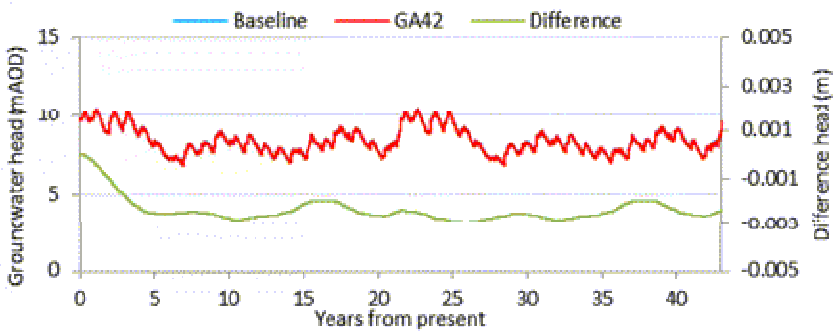


Figure 7-7-6 Groundwater levels and difference at Merthyr Mawr – Run GA42 (Model Cell 45)

Baseline (blue) and development run (red), difference (green) is development run minus baseline (positive means a rise in water level). NB Baseline not visible as it is so similar to development run.

Summary of uncertainties

In summary, it is concluded that the predictions made by the model are robust and unaffected by the small amount of residual uncertainty in the conceptual model.

However, whilst, the quality of the model calibration and the results of the sensitivity analysis provide a strong measure of confidence in the predictions, in any project involving large scale excavation, there is always the possibility that ground conditions may differ from those anticipated. The water management measures described in Appendix 7/5 include contingency measures for dealing with conditions outside the range predicted. Section 7.8 includes discussion of the results of model scenarios to demonstrate the potential effectiveness of different pumping strategies in controlling water levels at a distance from the quarry.

7.7 Potential Impacts of Combined Quarry Developments: Cornelly, Grove and Gaens

These effects and impacts are assessed by comparing the results of the baseline run with the combined quarries runs (ALL15 and ALL42).

7.7.1 A: General effects on groundwater levels and flows (combined development)

Groundwater Levels

At full scale development of all quarries there are greater predicted drawdowns relative to the baseline in the immediate vicinity of each quarry. Groundwater level rises are also generated in response to patterns of water disposal. Thus, rises are seen in the area around Pant Mawr and immediately to the north of Gaens. In all other areas there is a decline in water levels. However, the larger changes in groundwater level continue to be localised around the quarries. Effects on individual receptors are discussed below.

Groundwater Flows

There are further increases in groundwater flows as a result of combined quarry development. These effects are largest in the immediate vicinity of the quarries and are once again strongly affected by the pattern of dewatering disposals in each scenario. These effects are not expected to have significant regional effects.

Quarry Dewatering

The model predicts that average pumping rates required to dewater the various quarries at full combined development will be around:

Cornelly: 2990 m^3/d (-75 mAOD) - to Pant Mawr;

Grove: 1640 m^3/d (-15 mAOD) – to railway cutting;

Gaens: 4080 m^3/d (-20 mAOD) - to northern quarry sump.

These are long term average values; the actual rate in any one month will depend strongly on the amount of rainfall and the way in which the quarry is being worked at that time. Dewatering records at Cornelly Quarry indicate that weekly average pumping rates may vary by +/-50% from the average.

The accuracy of pumping rate predictions at Grove and Gaens are more uncertain than those derived for Cornelly due to the lack of historic data and less certainty about hydrogeological conditions at depth.

The relatively high rate at Gaens reflects the effect of groundwater flow from the nearby discharge to Pant Mawr.

Swansea Southern Carboniferous Limestone groundwater (Water Framework Directive) body

The simulated changes in groundwater level and flow are considered to have a **Negligible** impact on the quantitative status of the Swansea Southern Carboniferous Limestone groundwater (Water Framework Directive) body.

7.7.2 B: Potential effects on water levels in the dune sands at Kenfig Pool and Dunes SSSI and the Merthyr Mawr SSSI (combined development)

The combined effects of all three quarries is to produce reductions in water levels at both Kenfig and Merthyr Mawr (in contrast to the Cornelly only runs where a slight rise is simulated in Kenfig due to the location of water disposal). However, the changes are small, with a maximum reduction in simulated five year mean water levels of not more than 1 cm and maximum change in water levels during the entire run period of around 1 cm at Kenfig (Figure 7.8).

At Merthyr Mawr SAC there is a reduction in five year mean levels relative to baseline of not more than 1.5 cm and a maximum reduction during the full run period of the same amount (Figure 7.9). This compares with inter-annual variations at the two sites which are of the order of metres. Flows from Burrows Well, which discharges into the Merthyr Mawr Blown Sand aquifer are also little affected with five year mean flows decreased by less than 1% relative to baseline (Figure 7.10).

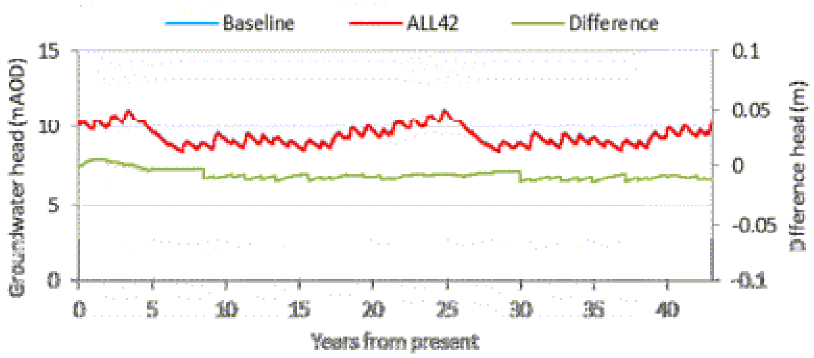


Figure 7-7-7 Groundwater levels and difference at Kenfig – Run ALL42 (Model Cell 55)

Baseline (blue) and development run (red), difference (green) is development run minus baseline (positive means a rise in water level). NB Baseline not visible as it is so similar to development run.

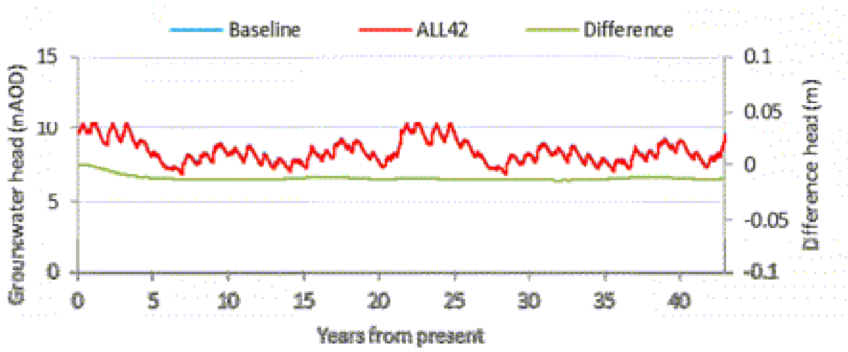


Figure 7-7-8 Groundwater levels and difference at Merthyr Mawr – Run ALL42 (Model Cell 45)

Baseline (blue) and development run (red), difference (green) is development run minus baseline (positive means a rise in water level). NB Baseline not visible as it is so similar to development run.

The illustrations above show the baseline and development run heads at representative model cells at Kenfig and Merthyr Mawr for the full development run. Against the background variation the differences between the two hydrographs are imperceptible on the graphs. Only when the difference is plotted on a separate y-axis (green) is it observable. The difference is extremely small and shows no obvious long term trend downward or upward. In practice the differences simulated would be immeasurable in the field.

Figure 7-9 shows the simulated flows at Burrows Well. The maximum difference is not more than 50 m^3/d decrease and the minimum simulated flow is not less than 550 m^3/d. Differences throughout the run Figure 7-10 are always less than 5% (the critical change threshold being 10% – see Section 7.5.1) and average just under 1.5%.

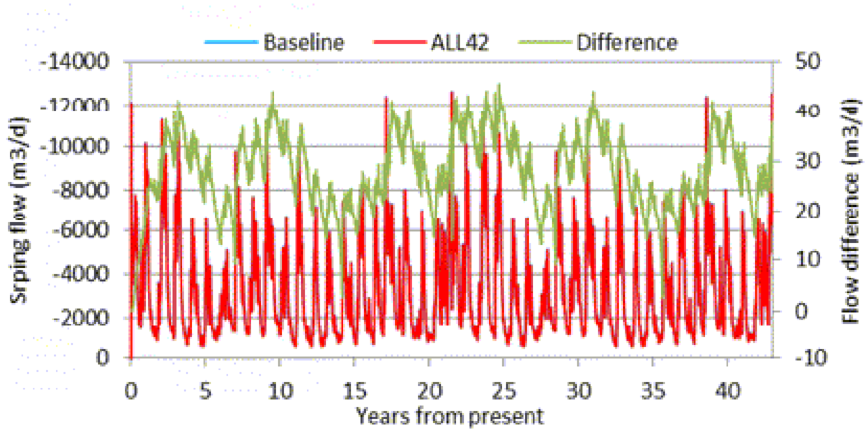


Figure 7-7-9 Flows at Burrows Well – Run ALL42

Baseline (blue) and development run (red), difference (green) is development run minus baseline (positive means decrease in flow). NB Baseline not visible as it is so similar to development run.

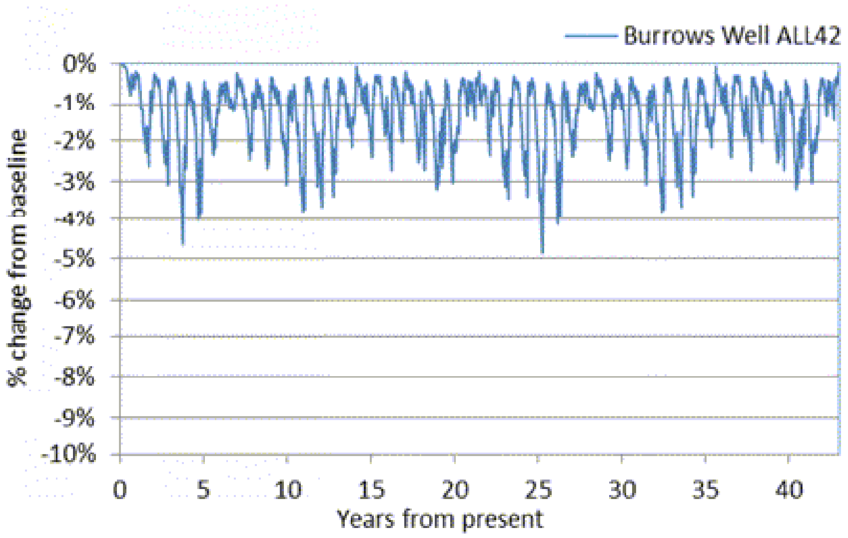


Figure 7-7-10 Changes in Burrows Well flow (as % change from baseline) – Run ALL42

The hydrological effect of development of all quarries combined on the Blown Sand aquifers at Kenfig and Merthyr Mawr is therefore judged to be **Negligible in hydrogeological terms**.

As noted above, the potential indirect effects on habitats within the Kenfig SAC are considered in Chapter 6.0 of the ES.

7.7.3 C: Potential effects on water levels and flows at other receptors (combined development)

The flow network model simulates that the future development of the quarry will not have a significant impact at the majority of the potentially vulnerable receptors/groups of receptors identified in the study area. For seven of the receptors, potentially significant effects have been identified as discussed below.

Ty Talbot Farm, Nottage (Loc. 18b): This well is predicted to experience a drawdown of five year mean levels by around 0.6 m (for the full development scenario) relative to baseline. This exceeds the critical change of 0.5 m (Section 7.5.1) for both the 15 year and full development scenarios. The model suggests a natural variation in groundwater levels of around 11 m and therefore, for the same reasons as discussed for Home Wood (Loc. 33) in Section 7.6, whilst these sites have been flagged up as being potentially vulnerable, site specific considerations indicate a low potential for impact.

Wilderness Pond (Loc. 20): This pond is predicted to experience a drawdown of five year mean levels by just over 0.6 m (for the full development scenario) relative to baseline. The critical change in levels here is 0.1 m (Section 7.5.1 , Appendix 7/5), otherwise the situation here is the same as at Ty Talbot Farm which is located nearby. Furthermore, the simulated natural variation of 11 m simulated here is clearly not experienced by the pond. This receptor is located close to the coast in a large model cell and so the variation and effect seen here is likely to be less.

The well at White Wheat (Loc. 21): The situation here is the same as at Ty Talbot Farm which is located nearby.

Pwll y Waun pond (Loc. 23): The situation here is the same as at Wilderness Pond which is located nearby.

Home Wood (33): This shallow well (NB. there is also a spring box and pond (Loc. 34) in the field to the north west) is predicted to experience a drawdown of five year mean levels of up to 0.5 m relative to baseline. This exceeds the critical change of 0.25 m (Section 7.5.1 , Appendix 7/5) in the 15 and 42 year scenarios. However, for the reasons discussed in Section 7.6, whilst these sites have been flagged up as being potentially vulnerable, site specific considerations indicate a negligible impact.

The pond at location 34 (Loc. 34): The simulated change in water level at this location is the same as at Home Wood which is located nearby. However, in this case the critical threshold is set at 0.1 m reduction (Section 7.5.1 , Appendix 7/5).

Grove Golf Club (Loc. 40): The reduction in five year mean water levels relative to baseline at this location is predicted to be just under 3.8 m for the full development scenario. For both 15 year and full development scenarios the drawdown exceeds the critical threshold of 0.5 m (Section 7.5.1). Simulated natural variation in levels at this location is just under 20 m so this does represent a potentially significant change.

In general, the simulated effects on groundwater flows in cells which represent selected receptors are not more than minor:

- Five year mean flows at New Mill Farm Springs (which should be taken to also include the potential effects on groundwater abstractions in this area) are predicted to show a potentially significant increase (around 11%) for the both 15 and 42 year scenarios.
- Five year mean net groundwater flows into Afon Fach/Railway Springs/Stormy Down Spring are predicted to decrease by a maximum of around 11% for the 15 year scenario (less than this for the 42 year scenario due to the locations of discharges from the quarries). This is slightly larger than the selected criterion for changes in stream flow (Section 7.5.1 , Appendix 7/5). However, given the inaccessible and developed location

of these springs (and therefore low amenity/ environmental value), this impact is concluded to be Negligible.
- At Parc Newydd Spring there is a temporary significant drop in five year mean groundwater levels (0.5 m) which may impact on spring flows.

The impact of development of all quarries combined as a result of change in water level or flow on Grove Golf Club (Loc. 40) is judged to be **Moderate**; at all springs and other receptors except Wilderness (Loc. 20) and Pwll y Waun (Loc. 23) (**Minor adverse**) it is judged to be **Negligible**.

7.7.4 D: Other potential effects (combined development)

Leachate Migration

Contingency measures to deal with scenarios such as the quarry intercepting a significant amount of landfill leachate are discussed in the WMP (Appendix 7/5).

Quarry Operations

See comments in Section 7.6.4.

Ground Stability

In this combined scenario, as Grove is being actively dewatered, the Cornelly discharge location has been simulated as reverting from Grove to Pant Mawr. Alternative locations such as Stormy Down or direct to the railway cutting could also be considered if necessary. However, as these are existing locations of quarry discharge for many years, this is unlikely to significantly change the conclusions of this report.

Saline Intrusion

The flow network model indicates that there is very little or no change to the amount of water flowing towards the coast – mean five year flows along critical flowpaths reduce by no more than 7% and the net change in total flow is around 4% over the full run period. This compares with a variation in flows under baseline conditions which is between approximately 60% higher and 40% lower than the mean (Figure 7.11)

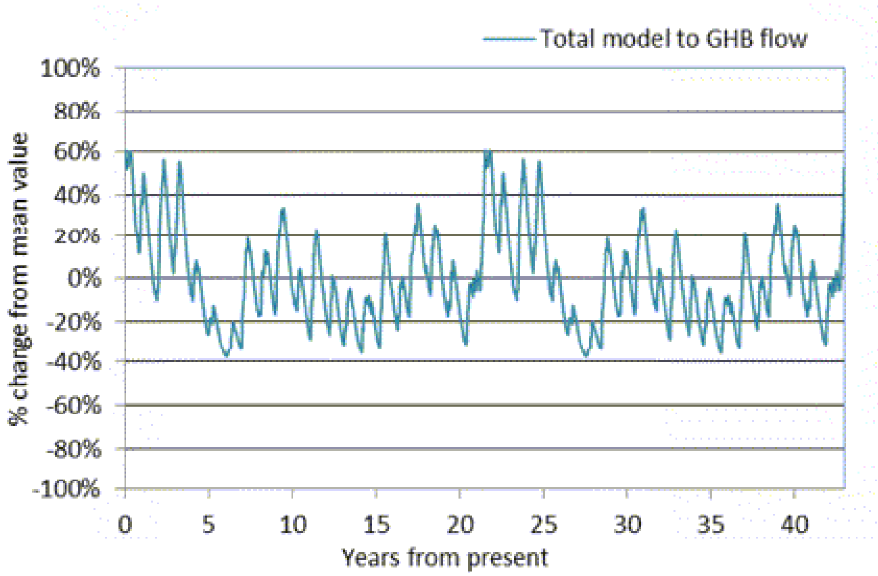


Figure 7-7-11 Variation in simulated outflow to the coast – Run BASELINE

As a result, it is considered that there is no significant risk that the proposed developments will cause saline intrusion. This is consistent with the fact that the proposed quarry developments only involve moving water from one part of the groundwater system to another rather than removing it to a different system.

Swansea Southern Carboniferous Limestone groundwater (Water Framework Directive) body

The simulated changes in groundwater level and flow are considered to have a **Negligible** impact on the groundwater quality status of the Swansea Southern Carboniferous Limestone groundwater (Water Framework Directive) body.

7.7.5 Uncertainty and Risk

The combined quarry scenario considered here makes some assumptions about how the quarries could operate together. Clearly there is some uncertainty as to how this will develop in future. This issue is considered in the Water Management Plan (Appendix 7/5).

7.8 Effects of Quarry Decommissioning

Once dewatering ceases, it will take a number of years for the quarry voids to fill up (discussed below). This creates the potential to cause some temporarily increased impacts at a number of receptors. It may therefore be necessary to maintain some residual pumping during dry periods to maintain outflows until natural groundwater levels are adequately restored. It should be noted that the natural groundwater levels reached after equilibrium has been established at some receptors may differ from those of the current baseline. This is discussed in more detail in Appendix 7/4 but is not discussed further here as the differences are not considered to be significant.

The RECOVERY run of the conceptual model does not include the effect of working the Grove IDO (base of working 15 mAOD)of the final recovery levels in this area are above 15 mAOD, and would have the effect of enhancing the effective transmissivity of the aquifer in this area (flat water surface). This is considered in the submission made in respect of the Grove IDO.

The results of the Gaens-only recovery run (GAENS RECOVERY) are presented in Appendix 7/4. They illustrate that the effects associated with recovery are dominated by Cornelly Quarry. For this reason they are not presented separately in this section and it is the results of the combined recovery that are presented. Whilst some options for residual mitigation (such as the residual pumping discussed below) should be retained for Gaens, it is anticipated that these will be much less significant than for Cornelly.

Once stabilised, the additional storage represented by the re-filled quarry voids will have the positive effect of giving the local groundwater system additional tolerance to droughts.

The flow network model has also been used to predict the effects on groundwater flows and cell water balance components following the cessation of quarrying. The model run RECOVERY has been used to represent the effects of post quarrying conditions following the cessation of quarrying at all three quarries.

A pair of residual pumping runs RECOVERY PUMPING 5 and RESIDUAL PUMPING 6 have also been undertaken to demonstrate the feasibility of reducing the degree of effects of recovery by maintaining a lower rate of dewatering from the quarries for a number of years after the cessation of normal operations. In RESIDUAL PUMPING 5 (used to demonstrate mitigation of effects at Kenfig) residual pumping was set to 50% of the full development run pumping rate at Cornelly and Grove Quarries (Gaens Quarry was switched off) with disposal to the railway cutting to the west of Grove Quarry. For RESIDUAL PUMPING 6 (used to demonstrate mitigation of effects at Merthyr Mawr) residual pumping was set to 50% of the full development run pumping rate at Cornelly only and this was directed to Stormy Down. Comparison of the results from these runs with the no mitigation scenario (RECOVERY) implies that this would be a feasible form of post development mitigation. Further runs to optimise the mitigation have not been carried out at this stage as this scenario is so far into the future.

A description of recovery model runs is presented in Table A7.4a in Appendix 7/4 and analysis of the results is presented in the text of the appendix.

7.8.1 A: General effects on groundwater levels and flows (Decommissioning)

Groundwater Levels

The effects of cessation of pumping are variable both spatially and in time. Full recovery of water levels in Cornelly Quarry may take around 30 years much faster responses occur in Grove and Gaens due to the smaller volumes.

At Cornelly and Grove, the water levels show a straightforward recovery (Figure 7-12) for recovery at Cornelly); conversely in the remainder of the model there is generally an initial period of decreasing heads (during the period when recharge is being diverted to fill the quarry voids) followed by gradual recovery to pre-quarrying levels as hydraulic gradients re-establish themselves.

In the absence of mitigation / residual pumping, these effects are greatest closest to the quarry, but small effects are simulated across a wide area.

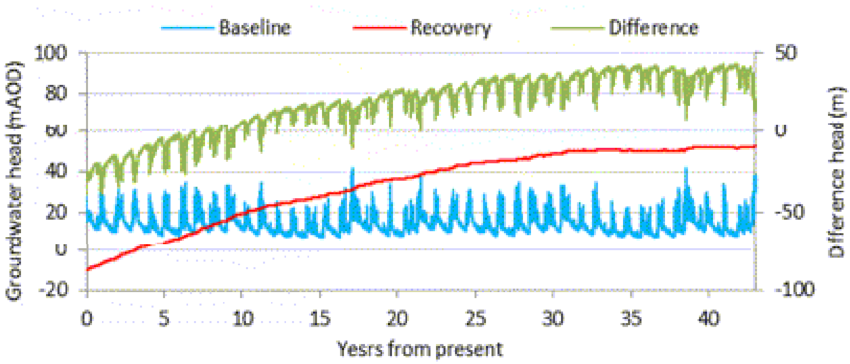


Figure 7-7-12 Groundwater levels at Cornelly – Run RECOVERY

Baseline (blue) and development run (red), difference (green) is development run minus baseline (positive means a rise in water level).

In terms of final levels the model simulates the average recovered water levels to be as follows for each of the quarries:

- Gaens – 28 m AOD
- Cornelly – 53 m AOD
- Grove – 21 m AOD

One effect of the restoration of the quarries to open water is that groundwater level fluctuations in and around the quarries will become more subdued due to the influence of the large storage capacity of the flooded quarry void. This effect is considered to be positive with respect to the water resources of the system by making it more tolerant to drought conditions.

Groundwater Flows

Some large changes in groundwater flow relative to baseline occur in the immediate vicinity of the quarries as a consequence of the cessation of dewatering. However, these changes are rapidly dampened with distance; away from quarries changes in groundwater flows relative to current conditions are limited to a few per cent.

It is noted that the flow network model does not make any allowances for the effect of changes to the rate of evaporation from the system following restoration as open water. Calculations presented by ESI to EA Wales (letter dated 23 August 2005, reference 6227SN006.doc) suggest that for the proposed restoration of Cornelly Quarry (open water area 25 ha) the additional evaporative loss is could be around 70 m^3/d. This effective abstraction rate is very small in relation to current and predicted dewatering rates from the system.

Swansea Southern Carboniferous Limestone groundwater (Water Framework Directive) body

The simulated changes in groundwater level and flow are considered to have a **Negligible** impact on the quantitative status of the Swansea Southern Carboniferous Limestone groundwater (Water Framework Directive) body.

7.8.2 B: Potential effects on water levels in the dune sands at Kenfig SAC / Kenfig Pool and Dunes SSSI and the Merthyr Mawr SSSI (Decommissioning)

Kenfig SAC/Kenfig Pool and Dunes SSSI

At Kenfig the general effect of the unmitigated recovery (RECOVERY) is for simulated levels to fall slightly initially (due to the cessation of pumping westwards) and then to recover gradually over subsequent years Figure 7.13. The maximum simulated short term (a few years) reduction in levels relative to baseline is 10 cm at Kenfig Pool (Cell 53) and around 12 cm in the dunes to the west of the pool (Cell 55). These peaks occur in drought periods when the baseline run shows elevated heads relative to naturalised (i.e. the apparent 'drawdown' here is because the baseline is higher than naturalised). Generally the differences from baseline are much smaller than this (a few centimetres). In the dunes to the north and north west the maximum change over the period is just under 3.5 cm.

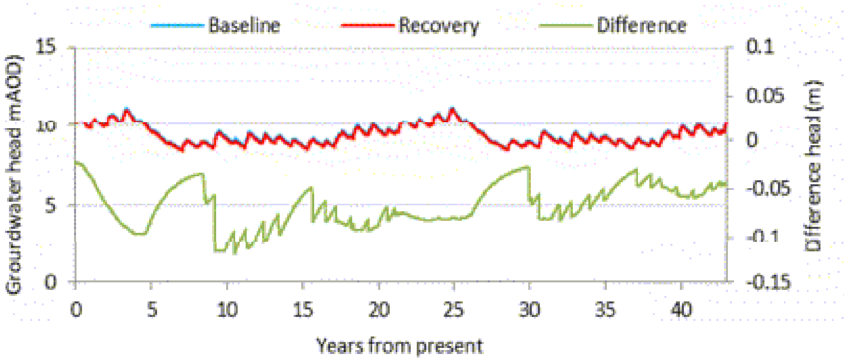


Figure 7-7-13 Groundwater levels at Kenfig – Run RECOVERY (Model Cell 55)

Baseline (blue) and development run (red), difference (green) is development run minus baseline (positive means a rise in water level). NB Baseline not visible as it is so similar to development run.

Whilst the critical threshold of 0.1 m is temporarily exceeded in the Kenfig Blown Sand aquifer immediately west of Kenfig Pool under unmitigated recovery conditions, residual pumping effectively prevents exceedance of the threshold (Figure7-14). The residual pumping scenario markedly reduces simulated effects on water levels at Kenfig; resulting in smaller changes over the period of pumping but a longer recovery and slightly larger changes than unmitigated recovery beyond the period of pumping (i.e. some deferral of effects). The simulated short term maximum reduction at Kenfig Pool is just under 8 cm relative to baseline; in the dunes to the west it is just under 10 cm; and in the other parts of the dunes it is just under 3.5 cm.

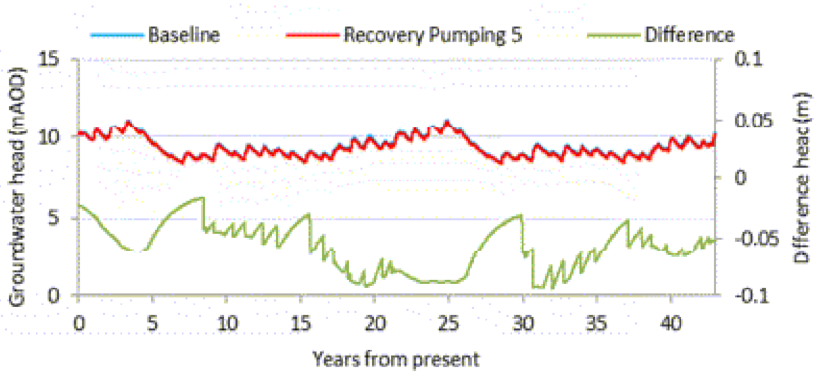


Figure 7-7-14 Groundwater levels at Kenfig – Run RECOVERY PUMPING 5 (Model Cell 55)

Baseline (blue) and development run (red), difference (green) is development run minus baseline (positive means a rise in water level). NB Baseline not visible as it is so similar to development run.

Merthyr Mawr SSSI

At Merthyr Mawr a similar trend is simulated (Figure 7-15) although the change here is from an initial decrease relative to baseline to just under a 5 cm increase by the end of the run. However, unlike at Kenfig, the maximum change is maintained at the end of the simulation period. This represents a return towards the theoretical naturalised conditions which would be higher than baseline due to the current diversion of disposal water from Cornelly westwards, away from Merthyr Mawr. Cells 42 and 43, whilst not being used as an indicator of groundwater level changes in the Blown Sand aquifer do show decreases which are greater than the 0.1 m critical threshold; however, this is due to starting head issues and is discussed in detail in Appendix 7/4.

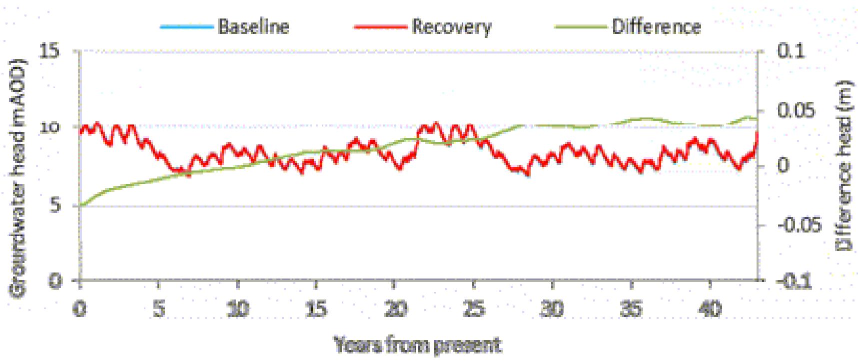


Figure 7-15 Groundwater levels at Merthyr Mawr – Run RECOVERY (Model Cell 45)

Baseline (blue) and development run (red), difference (green) is development run minus baseline (positive means a rise in water level). NB Baseline not visible as it is so similar to development run.

Figure 7-16 shows the simulated flows at Burrows Well under un mitigated conditions. There is an initial decrease of just under 50 m3/d relative to baseline which then progresses to an increase of around 150 m^3/d by the end of the run. The initial reduction is less than 4% on average and, whilst the magnitude of the final change is just under 6% on average over the last 5 years it is positive and therefore does not exceed the critical threshold of 10% reduction in long term flows (Section 7.5.1).

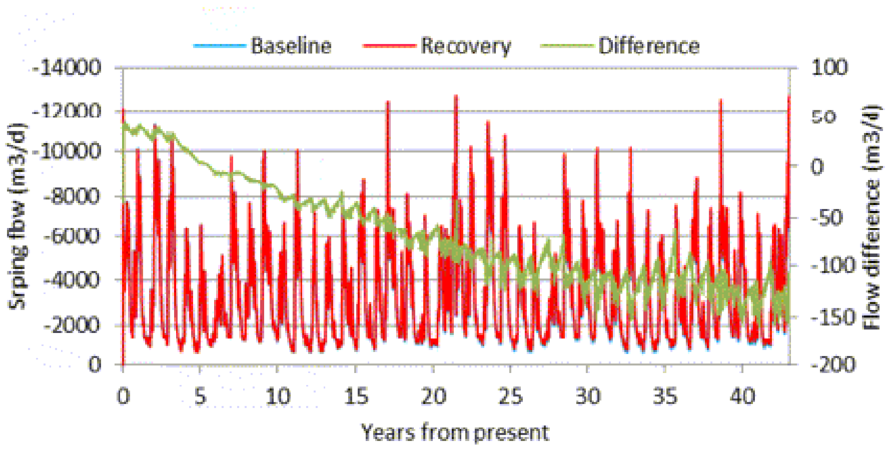


Figure 7-7-16 Flows at Burrows Well – Run RECOVERY

Baseline (blue) and development run (red), difference (green) is development run minus baseline (positive means a rise in water level). NB Baseline not visible as it is so similar to development run.

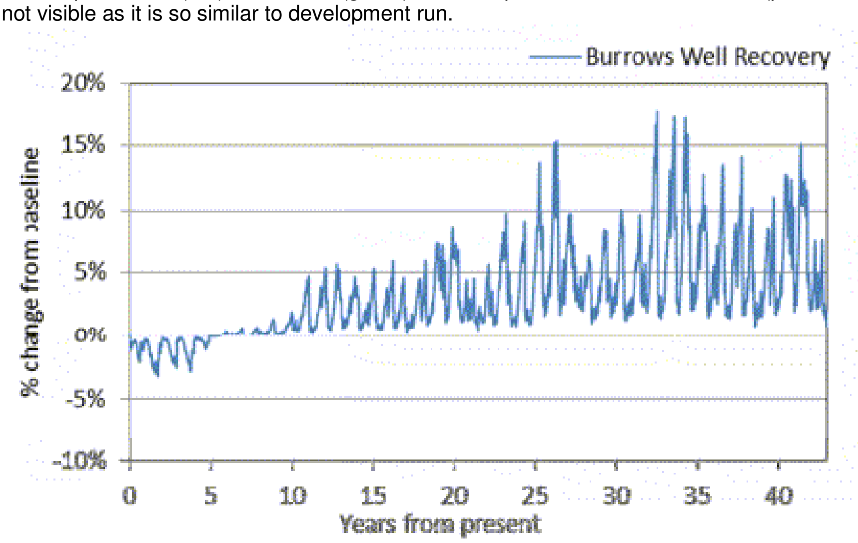


Figure 7-7-17 Changes in Burrows Well flow (as % change from baseline) – Run RECOVERY

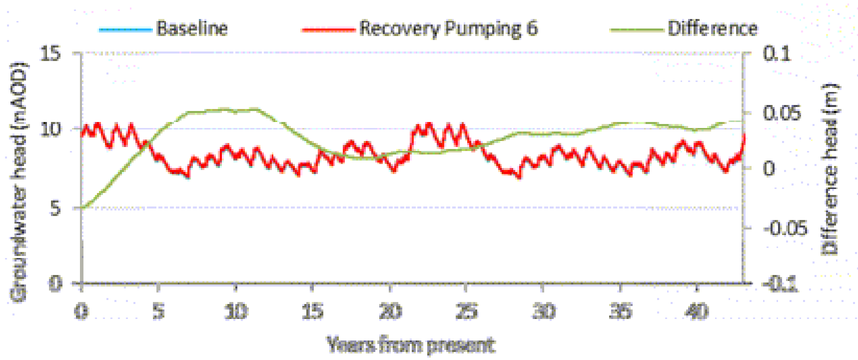


Figure 7-7-18 Groundwater levels at Merthyr Mawr – Run RECOVERY PUMPING 6 (Model Cell 45)

Baseline (blue) and development run (red), difference (green) is development run minus baseline (positive means a rise in water level). NB Baseline not visible as it is so similar to development run.

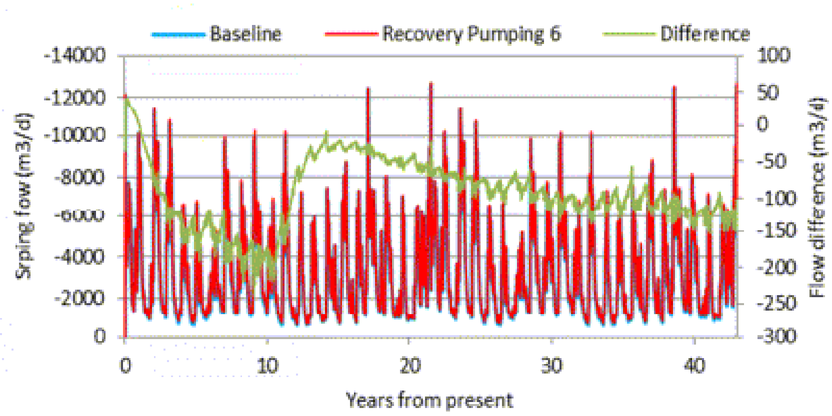


Figure 7-19 Flows at Burrows Well – Run RECOVERY PUMPING 6

Baseline (blue) and development run (red), difference (green) is development run minus baseline (positive means a rise in water level). NB Baseline not visible as it is so similar to development run.

Summary

It should be noted that the results presented for Kenfig and Merthyr Mawr above represent the cells in the model that are most affected in the recovery run. Cell 55 at Kenfig is particularly sensitive to flows coming out of Kenfig Pool compared to the other dune cells and the equivalent changes in adjoining cells are far more attenuated and less than 3 cm in all cases.

Without mitigation the impact of development of all quarries combined on the Blown Sand aquifers at Kenfig is judged to be **Negligible** in hydrogeological terms but requires further ecological assessment due to short term exceedance of the screening threshold of 10 cm as the lower limit of delectability to a modelled 12 cm over a short period (a few years). With mitigation it does not exceed the screening threshold and the impact is judged to be **Negligible**.

At Merthyr Mawr it is judged to be **Negligible both without and with mitigation.**

Consistent with the comments above, the potential indirect effects on habitats within the Kenfig SAC are considered in Chapter 6.0 of the ES. .

7.8.3 C: Potential effects on water levels and flows at other receptors (Decommissioning)

The decommissioning scenario without mitigation measures shows temporary potentially significant effects on a number of the identified receptors during the period of quarry filling. These are:

- Royal Porthcawl Golf Club well (Loc. 14)
- Ty Tanglwyst Farm pond (Loc. 17)
- Ty Tanglwyst Farm well (Loc. 17a)
- Ty Talbot Farm, Nottage (Loc. 18b)
- Wilderness Pond (Loc. 20)
- The well at White Wheat (Loc. 21)
- Pwll y Waun pond (Loc. 23)
- The well at Home Wood (Loc. 33)
- The pond at location 34 (Loc. 34)
- Royal Porthcawl Golf Club well (Loc. 36)

- Grove Golf Club well (Loc. 40)
- Tynycaeau (Loc. 61)
- Pyle & Kenfig Golf Course (Loc. 65)

For all but Grove Golf club (Loc. 40) whilst the effects of groundwater level changes are greater than the critical threshold (0.5 m – see Section 7.5.1 , Appendix 7/5), they are generally small when compared with the natural variation in the aquifer.

In general, the predicted effects on groundwater flows in cells which represent selected receptors are small:

- Flows over the simulation period at New Mill Farm Springs (which should be taken to also include the potential effects on groundwater abstractions in this area) are predicted to show an initial decrease relative to baseline, with short term decreases of more than 10% during the first four years (but with annual average decrease less than this). The reduction in flows decreases over time until, after about 25 years, the difference in flows becomes positive (peaking at around 15% increase). The use of recovery pumping reduces the effect to less than a 10% decrease initially up to a maximum of around 10% increase at the end of the simulation.
- Mean net groundwater flows into Afon Fach/Railway Springs/Stormy Down Spring show just over 20% increase over the simulation period.
- At Parc Newydd Spring there is a temporary potentially significant drop in groundwater levels (1.6 m) which may impact on spring flows.

In the absence of mitigation / residual pumping, the impact of recovery of the quarries as a result of change in water level or flow on Grove Golf Club (Loc. 40) is judged to be **Moderate adverse**; at Parc Newydd Spring the impact is **Minor adverse**; all other springs it is judged to be **Negligible**; at the remaining receptors listed above the impact is judged to be **Minor adverse**; and at other receptors it is judged to be **Negligible**.

With mitigation / residual pumping the effects are generally reduced although not enough to change the impact categorisation from the unmitigated case.

7.8.4 D: Other potential effects (Decommissioning)

Leachate Migration

Flows toward the quarry are initially higher than baseline due to the way it has been modelled. However, after 5 years and, apart from short-lived spikes, flow toward the quarry is less than baseline. There the risk of increased leachate migration toward the quarry is reduced as a result of the recovery.

Flow through Tythegston remain positive (i.e. coastward away from Cornelly) throughout the recovery. There is therefore no increased risk of leachate migration.

There appears to be some contaminated groundwater in the immediate vicinity of Gaens Quarry and any dewatering and disposal of groundwater in this area may act to dilute and disperse these contaminants.

Ground Stability

This is not an issue in the decommissioning scenario.

Saline Intrusion

Comparison with the baseline run indicates that flows initially decrease by just under 9. As recovery progresses the reduction in flow lessens. Based on this and seen in the context of natural variation of levels (as discussed in Section 7.7.4), no significant change to coastal outflows relative to pre-quarrying conditions is predicted as a consequence of ceasing quarry activity.

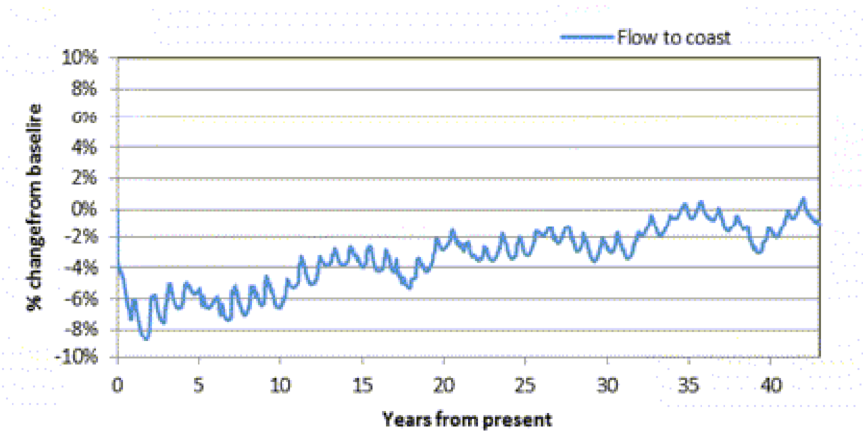


Figure 8-7-20 Changes in coastal outflow (as % change from baseline) – Run RECOVERY

Swansea Southern Carboniferous Limestone groundwater (Water Framework Directive) body

The simulated changes in groundwater level and flow are considered to have a **Negligible** impact on the groundwater quality status of the Swansea Southern Carboniferous Limestone groundwater (Water Framework Directive) body.

7.8.5 Uncertainty and Risk

As with the combined quarry operation scenario, there are uncertainties about when the various quarries will be restored, although timescales are provided in the impact assessments based upon reasoned assumptions regarding reserves and projected future output, and, in the case of Gaens, an assumed resumption of operations. The assumption used in this section is that quarrying operations will be completed simultaneously and that they will be restored concurrently from the maximum quarry development limits, which is a conservative assumption.

7.9 Summary of Pre-Mitigation Effects

A summary of the pre-mitigation effects is provided in the following tables:

Table 7-12 Summary of Pre-Mitigation Potential Impacts: Gaens Quarry Development (Including Combined Effects)

ESI map ref.	Location Name	Type of Receptor	Potential Impact	Assessment Criteria	Effect Assessment	Degree of Effect	Receptor Status	Significance of Impact	Mitigation Requirement
Site Specific Impacts									
-	Kenfig dune slacks	Dune slacks	Long-term decline in groundwater levels greater than 0.1 m. Ecological impacts dealt with under separate ecological assessment)	Predicted GWLs at dunes & Predicted water balance effects	Predicted reduction in groundwater level significantly less than critical threshold (10 cm) reaching 1 cm (full model period).	Negligible	High	Negligible (see also ecological assessment).	
-	Merthyr Mawr dune slacks	Dune slacks	Long-term decline in groundwater levels greater than 0.1 m. Ecological impacts dealt with under separate ecological assessment)	Predicted GWLs at dunes & Predicted water balance effects	Predicted reduction in groundwater level in main dune area (cells 44 and 45) significantly less than critical threshold (10 cm) reaching around 1 cm (full model period).	Negligible	High	Negligible (see also ecological assessment).	
1	Alpha Floc Well/borehole	Borehole	Reduction in borehole performance / yield due to dewatering abstraction	Predicted water balance effects	Water level decreases well below critical threshold under all model scenarios therefore impacts judged to be insignificant. Result expected owing to the close continuity of the drift deposits (from which the borehole is thought to abstract) with the Afon Kenfig. Abstraction also north of both Afon Kenfig and New Mill Fm springs which are likely to fix local	Negligible	Low	Negligible	

					groundwater levels.				
			Reduction in water quality due to groundwater pollution (accidental fuel spills, leaks etc. within quarry)	Conceptual understanding	No impact anticipated due to the distance of the well from Gaens quarry and the intervening effects of both the Afon Kenfig and New Mill Fm springs	Negligible	Low	Negligible	
2	Kenfig Industrial Estate	SW abstraction	Reduced abstraction potential due to reduction in stream baseflow contribution	Predicted water balance effects	Surface water abstraction from Afon Kenfig will not be impacted upon by quarry dewatering - simulated flow balances for shows very minor or positive changes to groundwater flows toward the river (and therefore by inference river baseflow) as a result of full-scale quarry development.	Negligible	Low	Negligible	
3	Borg Warner well, Industrial Estate	Borehole	Reduction in borehole performance / yield due to dewatering abstraction	Predicted water balance effects	As site 1.	Negligible	Low	Negligible	
			Reduction in water quality due to groundwater pollution (accidental fuel spills, leaks etc. within quarry)	Conceptual understanding	No impact anticipated due to the distance of the well from Gaens quarry and the intervening effects of both the Afon Kenfig and New Mill Fm springs	Negligible	Low	Negligible	
4	Chapel Spring	Spring	Reduction in spring flows due	Predicted water balance effects	Only very minor reduction in groundwater inflows predicted as a consequence of full	Low	Medium	Minor	

			to dewatering abstraction		scale Cornelly dewatering; thus no significant change in average spring flows anticipated. Result expected owing due to a limited hydrogeological connection with Gaens quarry.				
5a/b, 60	New Mill Farm Springs	Spring	Reduction in spring flows due to dewatering abstraction	Predicted water balance effects	Reductions in spring flow negligible or positive so no significant negative impact.	Negligible	High	Negligible	
14	Royal Porthcawl Golf Club	Borehole	Reduction in borehole performance / yield due to dewatering abstraction	Predicted GWLs at the well site	Water level decreases below critical threshold under all model scenarios therefore impacts judged to be insignificant.	Negligible	Low	Negligible	
			Reduction in water quality due to groundwater pollution (accidental fuel spills, leaks etc. within quarry)	Conceptual understanding	Risk of well contamination very low due to the distance between the source and receptor and the absence of an established pathway.	Negligible	Low	Negligible	General requirement to control of pollution hazards on site
			Induced saline intrusion due to effects of dewatering abstraction	Predicted GWLs at the well site	Slight increase in likelihood of saline intrusion due to reduced heads and slightly reduced coastal outflows; however, no reversal of gradient and flows are still seaward. Not judged to be significant.	Negligible	Low	Negligible	
17	Ty Tanglwyst Farm	Pond	Reduction in pond levels due to the effects of quarry dewatering	Predicted GWLs at pond	Groundwater level rises predicted so no negative impacts. Practical impacts limited since pond not used.	Negligible	Low	Negligible	
			Reduction in water quality due to groundwater pollution (accidental fuel spills, leaks etc. within quarry)	Conceptual understanding	No risk of water contamination from activities at Gaens Quarry	Negligible	Low	Negligible	General requirement to control of pollution hazards on site

17a	Ty Tanglwyst Farm	Borehole	Reduction in borehole performance / yield due to dewatering abstraction	Predicted GWLs at the well site	Groundwater level rises predicted so no negative impacts.	Negligible	Low	Negligible	
			Reduction in water quality due to groundwater pollution (accidental fuel spills, leaks, increased turbidity etc.)	Conceptual understanding	No risk of water contamination from activities at Gaens Quarry	Negligible	Low	Negligible	General requirement to control of pollution hazards on site
18b	Ty Talbot Farm, Nottage	Borehole	Reduction in borehole performance / yield due to dewatering abstraction	Predicted GWLs at the well site	Groundwater level changes exceed critical threshold in combined development scenarios; however natural groundwater variation considerably greater than predicted effect. Impact not considered significant.	Medium	Low	Minor	
			Reduction in water quality due to groundwater pollution (accidental fuel spills, leaks etc. within quarry)	Conceptual understanding	No risk of water contamination from activities at Gaens Quarry	Negligible	Low	Negligible	General requirement to control of pollution hazards on site
20	Wilderness	Pond	Reduction in pond levels due to the effects of quarry dewatering	Predicted GWLs at pond	As site 18b.	Low	Medium	Minor	
21	White Wheat	Borehole	Reduction in borehole performance / yield due to	Predicted GWLs at the well site	As site 18b.	Medium	Low	Minor	

			dewatering abstraction						
			Reduction in water quality due to groundwater pollution (accidental fuel spills, leaks etc. within quarry)	Conceptual understanding	No risk of water contamination from activities at Gaens Quarry	Negligible	Low	Negligible	General requirement to control of pollution hazards on site
23	Pwll y Waun	Pond	Reduction in pond levels due to the effects of quarry dewatering	Predicted GWLs at pond	As site 18b.	Low	Medium	Minor	
28, 30, 45	Collection of springs at Merthyr Mawr	Springs	Reduction in spring flows due to dewatering abstraction	Predicted water balance effects	Predicted reduction in net groundwater inflows to the area and Borrows Well flows are small (less than 5% at worst). No significant impacts therefore anticipated.	Low	Medium	Minor	
33	Home Wood	Shallow Well	Reduction in borehole performance / yield due to dewatering abstraction	Predicted GWLs at well site	As site 18b except that water level decreases below critical threshold in all scenarios.	Medium	Low	Minor	
			Reduction in water quality due to groundwater pollution (accidental fuel spills, leaks, increased turbidity etc.) resulting from quarry activities	Conceptual understanding	No risk of water contamination from activities at Gaens Quarry	Negligible	Low	Negligible	General requirement to control of pollution hazards on site

34	Pond	Pond	Reduction in pond levels due to the effects of quarry dewatering	Predicted GWLs at pond	As site 33.	Medium	Low	Minor	
36	Royal Porthcawl Golf Club	Borehole	Reduction in borehole performance / yield due to dewatering abstraction	Predicted GWLs at the well site	Groundwater levels do not exceed critical threshold so no significant impacts.	Negligible	Low	Negligible	
			Reduction in water quality due to groundwater pollution (accidental fuel spills, leaks etc.) resulting from quarry activities	Conceptual understanding	No risk of water contamination from activities at Gaens Quarry	Negligible	Low	Negligible	General requirement to control of pollution hazards on site
39a-e	Railway Springs	Spring	Reduction in spring flows due to dewatering abstraction	Predicted GWLs at spring & Predicted water balance effects	Limited impacts - greatest in combined 15 year scenario (up to 11% inflow reduction).	Medium	Low	Minor	Water level monitoring
40	Grove Golf Club	Borehole	Reduction in borehole performance / yield due to dewatering abstraction	Predicted GWLs at well site	As site 33.	Medium	Medium	Moderate	
			Reduction in water quality due to groundwater pollution	Conceptual understanding	No risk of water contamination from activities at Gaens Quarry	Negligible	Low	Negligible	General requirement to control of pollution hazards on site

			(accidental fuel spills, leaks, increased turbidity etc.) resulting from quarry activities						
54, 55	Kenfig Pond seep	Seep	Reduction in seeps due to dewatering abstraction	Predicted GWLs at seeps & Predicted water balance effects	Predicted change in water level less than 2 cm drop and less than 6% change in flow (mean over last 5 years). No significant impact.	Low	Medium	Minor	
			Reduction in water quality of seeps due to groundwater pollution (accidental fuel spills, leaks etc.) resulting from quarry activities	Conceptual understanding	No risk of water contamination from activities at Cornelly Quarry due to distance	Negligible	Medium	Negligible	
56/56N	Stormy Down Spring	Spring	Reduction in spring flows due to dewatering abstraction	Predicted GWLs at spring & Predicted water balance effects	As site 39a-e.	Medium	Low	Minor	
59	Parc Newydd Spring	Spring	Reduction in spring flows due to dewatering abstraction	Predicted GWLs at spring & Predicted water balance effects	Potentially significant impact due to a drop in levels under combined development runs (just under 0.5 m).	Medium	Low	Minor	
65	Golf club borehole	Borehole	Reduction in borehole performance / yield due to dewatering abstraction	Predicted GWLs at well site	As site 36.	Negligible	Low	Negligible	
			Reduction in water quality due to groundwater pollution (accidental fuel spills, leaks etc.) resulting from	Conceptual understanding	No risk of water contamination from activities at Cornelly Quarry	Negligible	Low	Negligible	General requirement to control of pollution hazards on site

			quarry activities						
KP	Kenfig Pool	Pond	Reduction in pond levels due to the effects of quarry dewatering	Predicted GWLs at pond & Predicted water balance effects	Predicted change in water level less than 2 cm drop (mean over last 5 years). No significant impact.	Negligible	High	Negligible	
61	Tynycaeau	Borehole	Reduction in borehole performance / yield due to dewatering abstraction	Predicted GWLs at well site	As site 36.	Negligible	Low	Negligible	
			Reduction in water quality due to groundwater pollution (accidental fuel spills, leaks, increased turbidity etc.) resulting from quarry activities	Conceptual understanding	There is a limited risk of water contamination from quarrying activities at this location.	Negligible	Low	Negligible	General requirement to control of pollution hazards on site
General Impacts									
-	Groundwater along coastal fringe	Groundwater	Induced saline intrusion	Predicted GWLs along coast	Very small changes in coastal outflow predicted. No reversal of gradient predicted.	Negligible	N/A	N/A	
-	Land directly surrounding quarry	Ground	Ground instability associated with dewatering extent	Conceptual understanding	Disposal of water from Cornelly Quarry is only to existing quarries and therefore there is no localised high flows which could induce washouts in fissures. No ground stability issues are anticipated	Negligible	N/A	N/A	

-	General groundwater quality	Groundwater	Disturbance of contaminated groundwater (aggravation of landfill leachate migration - Stormy West and Tythegston landfills)	Conceptual understanding Predicted water balance effects	Predicted groundwater flows suggest that the dewatering effects associated with Cornelly do induce some additional inflows to the quarry area from the former landfill sites (particularly from Stormy West). However, accounting for the absence of any significant migration of leachate to date, and the inferred anisotropy of the local aquifer system, there is considered to be no significant additional risk from landfill leachate migration.	Low	N/A	N/A	Precautionary water quality monitoring

*The base colour is for the scenarios with Gaens Quarry operating on its own. Where the assessment is different for the scenarios with all three quarries operating together, then this is overprinted as coloured stripes (using the same legend) in the 'Potentially Significant Impact' column only.

Key* : Potentially significant impact 15 year scenario; Potentially significant impact 42 year scenario

Key continued:

Magnitude of effect	Status of receptor	For lookup	Degree of impact
Negligible	Low	NegligibleLow	Negligible
Low	Low	LowLow	Minor
Medium	Low	MediumLow	Minor
High	Low	HighLow	Moderate
Negligible	Medium	NegligibleMedium	Negligible
Low	Medium	LowMedium	Minor
Medium	Medium	MediumMedium	Moderate
High	Medium	HighMedium	Major
Negligible	High	NegligibleHigh	Negligible
Low	High	LowHigh	Moderate
Medium	High	MediumHigh	Major
High	High	HighHigh	Major

Table 7-13 Summary of Potential Impacts: Gaens Quarry Restoration

ESI map ref.	Location Name	Type of Receptor	Potential Impact	Assessment Criteria	Effect Assessment	Degree of effect	Receptor Status	Significance of Impact
Site Specifics								
-	Kenfig dune slacks	Dune slacks	Long-term decline in groundwater levels greater than 0.1 m. Ecological impacts dealt with under separate ecological assessment)	Predicted GWLs at dunes & Predicted water balance effects	Predicted reduction in groundwater level temporarily less than critical threshold (10 cm) reaching around 12 cm at worst case. Effect is hydrogeologically negligible but requires further ecological assessment.	Negligible	High	Negligible (see also ecological assessment).
-	Merthyr Mawr dune slacks	Dune slacks	Long-term decline in groundwater levels greater than 0.1 m. Ecological impacts dealt with under separate ecological assessment)	Predicted GWLs at spring & Predicted water balance effects	Predicted temporary change in groundwater level of just under 15 cm exceeds critical threshold of 10 cm for 2 months initially - result of starting head selection. Remainder of run does not exceed critical threshold.	Negligible	High	Negligible (see also ecological assessment).
1	Alpha Floc Well/borehole	Borehole	Change in borehole performance / yield due to alteration of groundwater flow regime	Predicted water balance effects	Water level decreases well below critical threshold under all model scenarios therefore impacts judged to be insignificant. Result expected owing to the close continuity of the drift deposits (from which the borehole is thought to abstract) with the Afon Kenfig. Abstraction also north of both Afon Kenfig and New Mill Fm springs which are likely to fix local groundwater levels.	Negligible	Low	Negligible
2	Kenfig Industrial Estate	SW abstraction	Reduced abstraction potential due to modification of stream baseflows	Predicted water balance effects	Surface water abstraction from Afon Kenfig will not be impacted upon by quarry dewatering - simulated flow balances for shows very minor changes (<1%) to groundwater flows toward the river (and therefore by inference river baseflow).	Negligible	Low	Negligible
3	Borg Warner	Borehole	Change in borehole	Predicted water	As site 1.	Negligible	Low	Negligible

	well, Kenfig Indus		performance / yield due to alteration of groundwater flow regime	balance effects				
4	Chapel Spring	Spring	Alteration of spring flows due to changes in the groundwater flow regime	Predicted water balance effects	Only very minor reduction in groundwater inflows predicted; thus no significant change in average spring flows anticipated. Result expected owing due to a limited hydrogeological connection with Cornelly quarry.	Negligible	Medium	Negligible
5a/b, 60	New Mill Farm Springs	Spring	Alteration of spring flows due to changes in the groundwater flow regime	Predicted water balance effects	Long term flows do not exceed 6% reduction and are positive once stabilised so no significant negative impact.	Negligible	High	Negligible
14	Royal Porthcawl Golf Club	Borehole site	Change in borehole performance / yield due to alteration of groundwater flow regime	Predicted GWLs at the well site	Groundwater level changes exceed critical threshold; however natural groundwater variation considerably greater than predicted effect. Impact not considered significant.	Low	Low	Minor
17	Ty Tanglwyst Farm	Pond	Change in pond levels due to alteration of groundwater flow regime	Predicted GWLs at pond	Groundwater level changes exceed critical threshold; however natural groundwater variation considerably greater than predicted effect. Impact not considered significant. Practical impacts limited since pond not used.	Low	Low	Minor
17a	Ty Tanglwyst Farm	Borehole	Change in borehole performance / yield due to alteration of groundwater flow regime	Predicted GWLs at the well site	As site 14.	Low	Low	Minor
18b	Ty Talbot Farm, Nottage	Borehole	Change in borehole performance / yield due to alteration of groundwater flow regime	Predicted GWLs at the well site	As site 14.	Low	Low	Minor
20	Wilderness	Pond	Change in pond levels due to alteration of groundwater flow regime	Predicted GWLs at pond	As site 14.	Low	Medium	Minor

21	White Wheat	Borehole	Change in borehole performance / yield due to alteration of groundwater flow regime	Predicted GWLs at the well site	As site 14.	Low	Low	Minor
23	Pwll y Waun	Pond	Change in pond levels due to alteration of groundwater flow regime	Predicted GWLs at pond	As site 14.	Low	Medium	Minor
27, 28, 29 30, 31, 45	Collection of springs at Merthyr Mawr	Springs	Alteration of spring flows due to changes in the groundwater flow regime	Predicted GWLs at spring & Predicted water balance effects	Predicted reduction in net groundwater inflows to the area are small and changes in flows at Burrows Well are also small (less than 3% peak reduction followed by long term increase of around 6%). No significant impacts therefore anticipated.	Negligible	Medium	Negligible
33	Home Wood	Shallow Well	Change in borehole performance / yield due to alteration of groundwater flow regime	Predicted GWLs at well site	As site 14.	Low	Low	Minor
34	Pond	Pond	Change in pond levels due to alteration of groundwater flow regime	Predicted GWLs at pond	As site 14.	Low	Low	Minor
36	Royal Porthcawl Golf Club	Borehole	Change in borehole performance / yield due to alteration of groundwater flow regime	Predicted GWLs at the well site	As site 14.	Low	Low	Minor
39a-e	Railway Springs	Spring	Alteration of spring flows due to changes in the groundwater flow regime	Predicted GWLs at spring & Predicted water balance effects	Initial small drop in spring flows but averaging around 20% increase over model period.	Negligible	Low	Negligible

40	Grove Golf Club	Borehole	Change in borehole performance / yield due to alteration of groundwater flow regime	Predicted GWLs at well site	Potential temporary drop of around 9 m predicted. This is a significant proportion of the natural variation (around 19 m) and therefore is considered significant.	Medium	Medium	Moderate
54, 55	Kenfig Pond seep	Seep	Change in seep flows due to alteration of groundwater flow regime	Predicted GWLs at seeps & Predicted water balance effects	Maximum reduction in flows less than 10% of total flow variation.	Negligible	Medium	Negligible
56/56N	Stormy Down Spring	Spring	Alteration of spring flows due to changes in the groundwater flow regime	Predicted GWLs at spring & Predicted water balance effects	As 39a-e.	Negligible	Low	Negligible
59	Parc Newydd Spring	Spring	Alteration of spring flows due to changes in the groundwater flow regime	Predicted GWLs at spring & Predicted water balance effects	Potentially significant impact due to a drop in levels under combined development runs (around 1.6 m).	Medium	Low	Minor
65	Golf club borehole	Borehole	Change in borehole performance / yield due to alteration of groundwater flow regime	Predicted GWLs at well site	As site 14.	Low	Low	Minor
KP	Kenfig Pool	Pond	Change in pond levels due to alteration of groundwater flow regime	Predicted GWLs at pond & Predicted water balance effects	Predicted change in water level equals 10 cm. No significant impact.	Negligible	High	Negligible
61	Tynycaeau	Borehole	Change in borehole performance / yield due to alteration of groundwater flow regime	Predicted GWLs at well site	As site 14.	Low	Low	Minor
General Impacts								
-	Groundwater along coastal fringe	Groundwater	Induced saline intrusion	Predicted GWLs along coast	Groundwater level changes along the coastal fringe do not permit the reversal of hydraulic gradients necessary to induce saline intrusion.	Negligible	N/A	N/A

-	Land directly surrounding quarry	Ground	Ground instability associated with water level changes	Conceptual understanding	No ground stability issues are anticipated	Negligible	N/A	N/A
-	General groundwater quality	Groundwater	Disturbance of contaminated groundwater (aggravation of landfill leachate migration - Stormy West and Tythegston landfills)	Conceptual understanding Predicted water balance effects	There are no significant increases in flow from the landfill locations toward the quarries. Because of this, the absence of any significant migration of leachate to date, and the inferred anisotropy of the local aquifer system, there is considered to be no significant additional risk from landfill leachate migration.		N/A	N/A

Key : Potentially significant impact

7.10 Mitigation Measures: Water Management Plan (WMP)

The impacts identified on the water environment from the proposed development of Gaens Quarry are, in general, minor. The Scoping Direction requires that risks from residual uncertainties such as the chances of encountering a highly permeable feature at depth are considered. This potential has been considered and modelled, but the risk of intercepting a highly permeable feature is considered to be extremely low. Notwithstanding this, the simulated effects are minor and would take between 5 and 10 years to manifest themselves.

The potential and residual risks have been addressed by means of a monitor and mitigate strategy embedded in the revised Water Management Plan (WMP) for the site (Appendix 7/5). This sets out how the quarry abstraction and discharges will be managed and includes recommendations for associated monitoring, triggers levels and responses to triggers being breached. Figure 7.23 provides a flow chart illustrating the various processes involved in the WMP.

The WMP has previously been subject to extensive consultation with the regulators (Table 7-3 in Section 7.2.6). The version in Appendix 7/5 has now been updated for this Environmental Statement in response to comments made on previous versions and in light of the results of the current assessment as presented above.

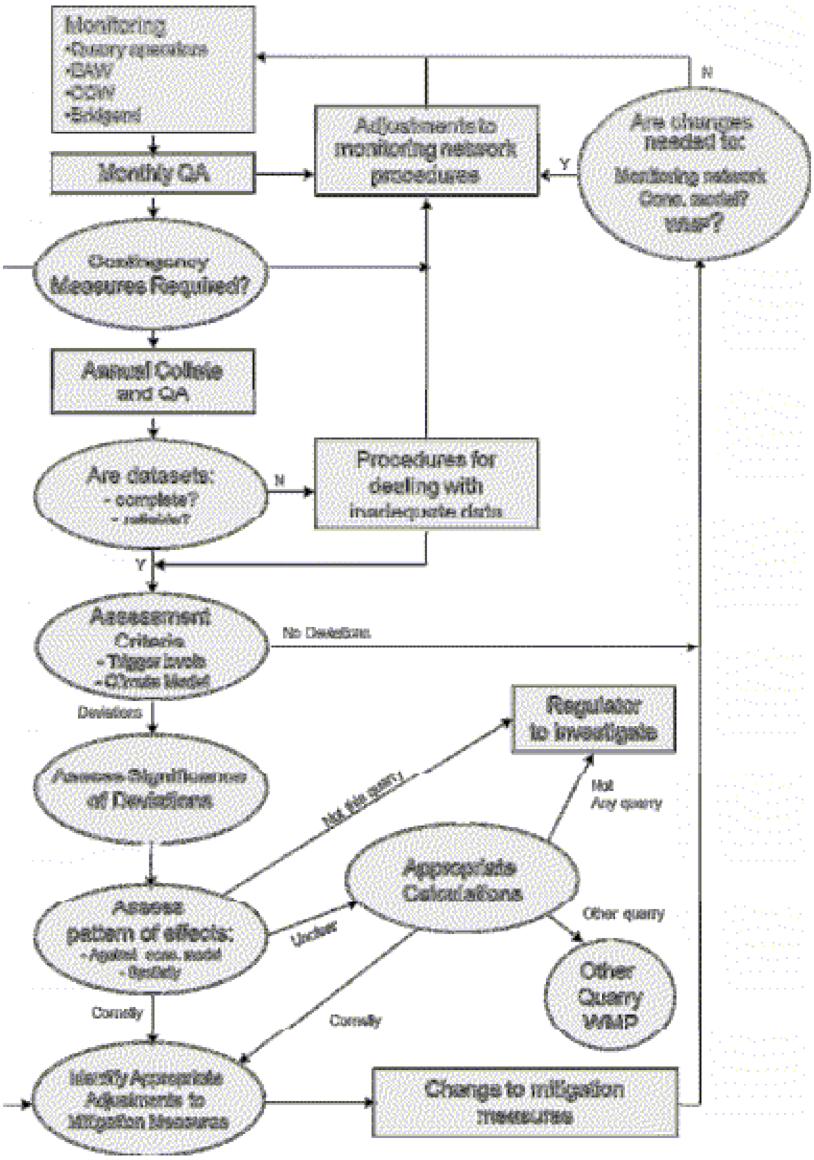


Figure 8-7-21 Processes in Water Management Plan

7.10.1 Disposal Options

Currently there is only a single disposal option for the discharge of water pumped from Gaens quarry sump, to the northern quarry sump.

7.10.2 Contingency Measures

The revised WMP includes a process for triggering Contingency Measures for eventualities which are outside the range of conditions that are considered to be realistic in this study.

The predictions of average dewatering rates are made on the basis of the most recent revision of the conceptual model described in Appendix 7/1. The conceptual model was based on a comprehensive review of all the data available, including a detailed review of the palaeokarst features in the quarry and in deep boreholes in the limestone. This indicated that there are unlikely to be any significant active fissures at depth below the quarry.

If this conceptual model is inaccurate and a 'highly permeable feature' were to be encountered, then the rates of inflow would be greater than predicted above. Whilst this is considered to be unlikely, the revised WMP includes a proposed procedure whereby the observed pumping rate at the quarry could be compared to the anticipated pumping rates (given antecedent rainfall) and any potentially significant change detected. Detection of such a change in pumping rate would trigger appropriate contingency measures, as set out in the WMP Section 6.3.3.

A potential threat to groundwater quality relates to increased rates of landfill leachate migration as a result of modified patterns of groundwater flow. The risk from this is judged to be small. However, the Water Management Plan contains an outline groundwater quality monitoring programme to identify any such pollution should it occur. It is anticipated that in future any discharges from the quarries will need to comply with appropriate water quality standards.

7.11 Residual Effects

A summary of the mitigation of significant effects (i.e. those where the impact is more than minor, or in the case of the SACs, where the screening threshold is passed) and the resulting residual effects are presented in Table 7.12 below. Following application of the mitigation measures residual effects are expected to be not more than **Minor in hydrogeological terms**.

Table 7-14 Potentially Significant Residual Effects and Proposed Mitigation[1]

Receptor	Description of effect	Degree of impact	Description of Mitigation	Resultant impact
Grove Golf Club	Reduction in groundwater levels at abstraction location during development and recovery.	Moderate	Application of WMP – Mitigation measures may include: • Modification of the structure of the abstraction • Provision of alternative supply • Financial compensation	Negligible
Kenfig SAC	Temporary reduction of groundwater levels past screening threshold during recovery relative to baseline conditions during drought periods.	Hydrogeological impacts are Negligible. See ecological assessment for potential indirect impacts. Under baseline conditions the existing quarry pumping is effectively ameliorating drought conditions to some extent.	Application of WMP – Maintain residual pumping during recovery period.	Critical screening threshold is not exceeded. Hydrogeological impacts are Negligible. See ecological assessment for potential indirect impacts.

[1]Signifcant = more than **Minor** or beyond critical threshold for SACs

7.12 Conclusions

Four categories of potential impact from the proposed quarrying activities (referred to in the assessment as A – D as described in Section 7.5.1) were identified by discussion with the relevant regulators. The likely extent of the various impacts has been addressed through a detailed programme of hydrogeological investigation (culminating in a robust conceptual model of the local hydrogeology) and subsequent groundwater flow simulation.

The volume of data collected for the site (including groundwater level, flow, and quality) and duration of monitoring records (greater than 10 years) represents a highly robust basis for this assessment.

The simulation of both groundwater flows and levels by a calibrated transient flow network model has facilitated a robust quantitative assessment to be made of the impacts associated with quarry development and decommissioning.

The conclusions to be taken from the impact assessment work are presented below in Table 7-15 in the context of the impact areas or categories

7.13 Recommendations

A draft Water Management Plan (WMP) has been drawn up to formalise future monitoring and management of abstraction/disposal at the quarries (Appendix 7/5).

7.14 Proposed Planning Conditions

The key planning condition requires the implementation of the Water Managament Plan and the obligations which it sets out for continual monitoring, assessment and mitigation measures if required.

A number of additional and conventional planning conditions would be appropriate to enshrine the fuel handling protocol to minimise the risk of ground and surface water contamination.

These issues are reflected in the updated schedule of proposed planning conditions.

:

Table 7-15 Impact/Risk Assessment Conclusions

	Impact Category (as per Scoping Direction)	Effect/Impact Category	Impact/Risk assessment conclusions
1	The potential impact of quarrying on Kenfig/Cynffig SAC/SSSIs and Cefn Cribwr Grasslands SAC/SSSIs.	B	Small predicted hydrogeological effects but no significant hydrogeological impact on Kenfig Pool and Dunes or Merthyr Mawr SSSIs. (The potential indirect effects on habitats within the Kenfig SAC are considered in Chapter 8.0 of the ES). Cefn Cribwr discounted as no effective hydrological pathway (Section 7.5.1).
2	The potential impact of quarrying on hydrology and hydrogeology of the area, including the possibility of interception during quarrying of a 'highly permeable feature' within the limestone, and although there is a low probability of this occurring the prospect should be recognised as a continuing risk during further development of the quarry and appropriate action identified (for example a risk management/monitoring strategy which recognises the critical stage at which potential adverse impact may occur).	A	Predicted impacts on the local hydrology are minor. Some effects but no significant impacts predicted for the 24 potentially vulnerable receptors. The likelihood of encountering a significant interconnected fissure at depth has been considered in detail and is concluded to be very low. The implications of encountering such a feature (if one did exist) have been considered by means of modelling which has informed the development of a Water management Plan for the site to tackle this residual uncertainty. The modelling work shows that the timescales for the effects of encountering such a feature to manifest themselves at key receptors are such that the proposed monitoring would provide sufficient warning to allow effective mitigation to be put in place.
3	The potential impacts on the Kenfig/Cynffig SAC and the hydrology of the dune system and Kenfig Pool, including the nature of the hydraulic connection between the dune sands and the underlying sand and gravel aquifer at Cynffig/Kenfig SSSI and the related sensitivity of groundwater levels in the dune sands to drawdown in the sand and gravel aquifer.	B	See 1.

	Impact Category (as per Scoping Direction)	Effect/Impact Category	Impact/Risk assessment conclusions
4	The potential impacts on other groundwater users and water features in the area.	C	See 2.
5	The potential for quarry dewatering to induce saline intrusion into the aquifer.	D	No significant risk of saline intrusion predicted (see Section 7.6.5).
6	The likely impact from further quarrying on the migration of leachate and landfill gas.	D	Further deepening of Cornelly Quarry will steepen the hydraulic gradient between the landfills and the quarry. However, careful consideration of this issue implies that this does not represent a significant risk (See Section 7.6.5). The Water Management Plan includes measures to monitor the quality of water pumped from the quarry sump.
7	The likely impact of quarrying on the stability of surrounding land.	D	It is not anticipated that the proposed discharge will cause any localised concentration of groundwater flow that could cause washout and hence some localised effects on ground stability (See Section 7.6.5).
8	An evaluation of potential surface lowering and sinkhole collapse.	D	It is not anticipated that the proposed discharge will cause any localised concentration of groundwater flow that could cause sinkhole development (See Section 7.6.5)

7.15 References

BGS, 2000, An assessment of the possible effects of dewatering proposed extensions to quarries in the South Cornelly area, South Wales

CEH, 2005. Determining a nitrogen budget for Merthyr Mawr sand dune system

EA, 2003a. email from B Cordier regarding clarification of conceptual model (11 November 2003)

EA, 2003b. email from S Neale regarding clarification of conceptual model (28 November 2003)

ESI, 2001. Scoping Request

ESI, 2002a. Cornelly Group of Quarries: Proposed Programme of Work for Phase 2 Hydrogeological Investigations

ESI, 2002b. The Hydrogeology of the area around the Cornelly Group of Quarries.

ESI, 2003a. Hydrogeological Investigations at the Cornelly Group of Quarries: Factual Report on Phase 2

ESI, 2003b. Conceptual Model of the Local Hydrogeology

ESI, 2003c. Letter addressed to EA Wales and CCW offering clarification of the conceptual model. Dated 12 November 2003. Reference 6227SN004.doc

ESI, 2004. Cornelly Group of Quarries: Impact Assessment for Cornelly Quarry and Combined Quarries

ESI, 2008. Cornelly Group of Quarries: Impact Assessment for Grove Quarry

ESI, 2010 Cornelly Group of Quarries: Impact Assessment for Gaens Quarry

ESI, 2009. Water Management Plan for Cornelly Quarry

Jones M L M, Pilkington M G, Healey M, Norris D A, Brittain S A, Tang Y S and Reynolds (CEH) 2005 Determining a nitrogen budget for Merthyr Mawr sand dune system. CCW R&D Report No. 14, Contract FC 72-02-59

Jones, P.S., 1993. Ecological and hydrological studies of dune slack vegetation at Kenfig NNR. Unpubl. PhD thesis. University College, Cardiff.

SWS, 2010. Refining river basin planning through targeted investigations on selected welsh groundwater dependent terrestrial ecosystems (GWDTEs)

8.0 NOISE

8.1 Introduction

This Chapter provides details of an assessment of environmental noise that has been carried out as part of the EIA with reference to British Standard and other Government guidance. The assessment considers the potential effects of noise relating to the continued operation of Gaens Quarry at the nearest noise-sensitive properties in the vicinity of the site.

Technical terms or references are occasionally used in this Chapter. To assist the reader, a glossary of terminology, including a table of example noise levels that may be found in general life, are included in Appendix 8/1.

The extent of the survey has been guided by the requirements of the scoping opinion issued by Welsh Government as set out in Appendix 1/1.

8.2 Government Advice, Standards and Good Practice

8.2.1 Minerals Technical Advice Note (Wales)

Minerals Technical Advice Note (Wales) 1: Aggregates (MTAN1) provides advice (paras 85-88) on controls and good practice to keep noise emissions from surface mineral working to acceptable levels without imposing unreasonable burdens on minerals operators.

MTAN1 gives no guidance on appropriate methods for predicting noise. However Mineral Planning Guidance 11: Control of Noise at Surface Mineral Workings (1993), which is referenced in MTAN1, recommends British Standard 5228 as being the appropriate method for predicting noise. Accordingly, BS5228:2009 Part 1 is summarised below.

8.2.2 British Standard 5228:2009

British Standard 5228:2009 *Code of practice for noise and vibration control on construction and open sites,* Part 1: *Noise* sets out a methodology for predicting noise levels arising from a wide variety of construction and related activities. As such, it can be used to predict noise levels arising from the operations of proposed minerals extraction sites. BS5228 also sets out tables of sound power levels generated by a wide variety of mobile equipment.

Noise levels generated by the site operations and experienced at local receptors will depend upon a number of variables, the most significant of which are:

- the amount of noise generated by plant and equipment being used at the development site, generally expressed as a sound power level;
- the periods of operation of the plant at the development site, known as the "on-time";
- the distance between the noise source and the receptor, known as the "stand-off";
- the attenuation due to ground absorption or barrier screening effects; and
- any reflections of noise due to the presence of hard vertical faces such as walls.

The noise predictions in this section have been undertaken using a proprietary software-based noise model, CadnaA, which implements the full range of UK calculation methods.

8.2.3 Local Planning Policy

Bridgend County Borough Council (BCBC) Local Development Plan (LDP) [1] Strategic Policy SP2 Design and Sustainable Place Making states:

> '*All development should contribute to creating high quality, attractive, sustainable places which enhance the community in which they are located, whilst having full regard to the natural, historic and built environment by:*
>
> *Avoiding or minimising noise, air, soil and water pollution;*'

Policy ENV7 Natural Resource Protection and Public Health states:

"*Development proposals will only be permitted where it can be demonstrated that they would not cause a new, or exacerbate an existing, unacceptable risk of harm to health, biodiversity and/or local amenity due to:*

> *1) Air pollution;*
>
> *2) Noise pollution;*
>
> *3) Light pollution;*
>
> *4) Contamination (including invasive species);*
>
> *5) Land instability;*
>
> *6) Water (including groundwater) pollution;*
>
> *7) Any other identified risk to public health or safety.*
>
> *Development in areas currently subject to the above will need to demonstrate mitigation measures to reduce the risk of harm to public health, biodiversity and/or local amenity to an acceptable level.*"

Policy ENV11 Mineral Development states:

> "*All mineral related developments, including underground gas extraction will be permitted only where all of the following criteria are satisfied:*
>
> *Measures will be taken to reduce damage or disturbance to neighbouring land uses to acceptable levels including:*
>
> *a) The effects of excessive noise, dust or vibration arising from the methods of working set out in a health impact assessment;*"

[1] Bridgend Local Development Plan 2006-2021 Adopted 18th September 2013

8.3 Consultation

Information regarding the proposed development, including plant utilisations associated with construction and operations, operational hours and proposed vehicles movements to and from the site has been supplied by the operator, T.S. Rees Limited.

Bridgend County Borough Council BCBC was consulted to confirm the views and policies on noise-related issues which may be associated with the proposed development and agreement was reached regarding the monitoring regime and assessment methodology.

BCBCB agreed that noise from the proposed development should be assessed in accordance with the guidance contained in MTAN1 and predictions should be made in accordance with the calculation methodologies contained in BS5228-1:2009.

The measurement protocol agreed with BCBC comprised representative measurements at local noise-sensitive receptors to cover the proposed working periods.

8.4 Assessment Approach

This assessment considers the likely noise levels that would be generated by the continued operations at the nearby noise-sensitive receptors.

An assessment has been made of the baseline situation and the potential impact of the proposals. Environmental advantages and disadvantages have been identified and where appropriate, mitigation measures and/or scheme changes to offset potentially adverse environmental impacts have been identified.

Operational noise levels generated by the mobile plant associated with operations at the site have been predicted using the methodology contained in BS5228-1:2009 and have been assessed against the guidance contained in MTAN1.

Noise levels generated by heavy goods vehicle movements have been assessed using the haul route method included within BS5228-1:2009.

8.5 Baseline Conditions

Environmental noise surveys were carried out at the noise-sensitive receptors closest to the site on 18th November 2013 to capture typical background noise levels.

The survey methodology and results are set out below.

The noise monitoring equipment used during the surveys is detailed in Appendix 8/2. All noise monitoring equipment was calibrated before and after the measurements and no calibration drifts were found to have occurred. The equipment had been calibrated to a traceable standard by UKAS-accredited laboratories within the 24 months preceding the surveys.

The noise monitoring or assessment locations, shown on Figure 8-1 below (and in Appendix 8/3), are considered as being representative of the nearest noise-sensitive locations to the proposed extraction area. These are:

Table 8-1

Location Ref	Location
Location 1	Cornelius Close to the northwest of the quarry;
Location 2	Rock Cottages to the west of the quarry;
Location 3	Mount Pleasant Road to the south of the quarry;
Location 4	Ty Tanglwyst Farm to the north of the quarry

Measurements were taken at each location over a one hour period during the daytime and a half hour period during the night-time.

At the measurement positions the following noise level indices were recorded:

$L_{Aeq,T}$ The A-weighted equivalent continuous noise level over the measurement period.

L_{A90} The A-weighted noise level exceeded for 90% of the measurement period. This parameter is often used to describe background noise.

L_{A10} The A-weighted noise level exceeded for 10% of the measurement period. This parameter if often used to describe road traffic noise.

L_{Amax} The maximum A-weighted noise level during the measurement period.

The weather conditions during the survey periods were acceptable for noise monitoring, being dry with little or no wind.

The microphone was placed 1.5m above the ground in free-field conditions, *i.e.* at least 3.5m from the nearest vertical, reflecting surface.

The results of the noise surveys are presented in full in Appendix 8/3 and are summarised in Tables 8-2 and 8-3 below.

Table 8-2 Summary of Measured Noise Levels - Weekday, free-field, dB

Location	$L_{Aeq,T}$	L_{A90}	L_{A10}	L_{Amax}
1 Cornelius Close	60.7	52.7	62.4	86.0
2 Rock Cottages	47.1	40.1	49.1	71.4
3 Mount Pleasant Road	57.4	40.1	51.8	85.4
4 Ty Tanglwyst Farm*	59.0	56.1	60.2	75.1

* - noise levels corrected by -6dB to account for the greater distance to the A4229 than the monitoring location.

Table 8-3 Summary of Measured Noise Levels – Sunday night, free-field, dB

Location	$L_{Aeq,T}$	L_{A90}	L_{A10}	L_{Amax}
1 Cornelius Close	45.7	31.9	39.8	71.5
2 Rock Cottages	31.0	25.2	31.5	58.9
3 Mount Pleasant Road	44.1	33.6	46.7	70.3
4 Ty Tanglwyst Farm*	45.2	35.3	46.8	71.9

* - noise levels corrected by -6dB to account for the greater distance to the A4229 than the monitoring location.

The daytime noise climate at Locations 1, 3 and 4 was dominated by local road traffic noise. Location 2 was affected by distant traffic noise from Porthcawl Road but was otherwise quiet. Quarry noise (from the Tarmac quarry rather than Gaens Quarry) was audible at Location 4 as a distant low rumble. Quarry noise from Gaens was not audible at any of the monitoring locations except for for the passage of HGV's from the site at Location 1.

8.6 Environmental Design Measures

The current operational layout of the site offers a good degree of protection to the amenity of the local residents by utilising the shielding effect of the quarry working faces and local landforms.

8.7 Potential Impact

MTAN1 contains the current government advice on noise from mineral extraction sites and is directly applicable to the proposed development.

Historically, this is an area which has been quarried over several years and it is considered that the daytime (07:00 to 19:00 hours) noise criterion of 10dB above background (as an $L_{Aeq,1hr}$) for normal daytime operations and the criterion of 67dB $L_{Aeq,1hr}$ for temporary operations of up to 8 weeks per year are appropriate for this assessment. Table 8.4 below shows the derived limits

Table 8-4 Summary of Noise Limits at noise-sensitive receptors, dB

Location	Background Noise Level, L_{A90}	Normal Operations Noise Limit $L_{Aeq,1hr}$	Temporary Operations Noise Limit $L_{Aeq,1hr}$
1 Cornelius Close	52.7	55.0	67.0
2 Rock Cottages	40.1	50.1	67.0
3 Mount Pleasant Road	40.1	50.1	67.0
4 Ty Tanglwyst Farm*	58.1	55.0	67.0

Night-time noise limits are detailed in MTAN1 and are fixed at 42dB(A) at any noise-sensitive receptor.

Plant items and a list of mobile noise sources have been provided by the applicant and are set out in Appendix 8/5 together with adopted sound power levels. The sound power levels are derived from discussions with the relevant plant manufacturers, monitoring of plant at a similar site or from tables contained in BS5228-1:2009. All sound power levels derived from measured data take into consideration the operation of any reversing warning systems fitted to the plant, where applicable.

8.8 Operational Assessment

The operational noise effects associated with the proposed development are anticipated to include the following:

- Excavation of the rock;
- Crushing of extracted rock;
- Transportation from the crusher to the stock handling area;
- Loading and transportation off site;
- Ancillary activities (site and plant maintenance, etc.); and
- Site reclamation.

The façade that faces towards the proposed extraction area has been considered for each of the noise-sensitive receptors.

8.8.1 Normal Operations

Noise predictions have been made based on the development scheme described in Chapter 3.0 of this ES, as shown on the application accompanying drawings and based on and subsequent discussions with the applicant.

The proposed phasing of the quarry development shows the existing excavation widened in stages to the north, south, west and east (Phases 1, 2, 3 and 4 respectively). The separation distances to the nearest noise-sensitive receptors change very little during the extraction the north, south and east.

Due to this minimal variation in separation distances it is considered that the predictions for noise levels due to existing activities will be representative of noise levels during Phases 1, 2 and 4.

Widening to the west significantly reduces the separation distances between quarry activities and nearby noise-sensitive properties. Additional predictions have therefore been made of noise levels during Phase 3 of operations.

The layout of Phase 3 operations would suggest that noisy activities will be carried out in close proximity (potentially 25m) to Rock Cottages whilst the upper tier of Phase 3 is being excavated. The excavation goes beyond the current crest of the ridge between the quarry and Rock Cottages, reducing the effectiveness of the landform as a noise barrier. As the excavation of the quarry deepens, the separation distance between noisy activities and Rock Cottages increases, as does the shielding effect from the ridge to the west of the quarry.

Excavation of the upper tier will consist of only one part of the excavations associated with Phase 3. For this reason it is considered appropriate to assess the excavation of the upper tiers (to the west) of Phase 3 against the 67dB limit for temporary operations specified within MTAN1. This would limit operations to up to 8 weeks per year.

The predictions are made to the facade of the nearby noise-sensitive receptors facing the site. The results of the predictions for various stages through the proposed development are shown in Tables 8.5 to 8.7 for each main phase of operations and are compared to the daytime and temporary operations nominal criteria adopted for this assessment.

Table 8-5 Predicted Noise Levels for Normal Operations – existing activities, free-field, dB

Location	Predicted Noise Level $L_{Aeq,1hr}$	Limit Daytime	Difference Daytime
1 Cornelius Close	40.2	55.0	-14.8
2 Rock Cottages	45.8	50.1	-4.3
3 Mount Pleasant Road	26.0	50.1	-24.1
4 Ty Tanglwyst Farm	40.0	55.0	-15.0

Table 8.6 shows that the predicted noise levels for normal operations during existing activities will be below the limits derived in accordance with the guidance contained in MTAN1 at all locations assessed.

Table 8-6 Predicted Noise Levels for Normal Operations – Phase 3, free-field, dB

	Predicted Noise Level $L_{Aeq,1hr}$	Limit Daytime	Difference Daytime
1 Cornelius Close	35.3	55.0	-19.7
2 Rock Cottages	49.4	50.1	-0.5
3 Mount Pleasant Road	31.6	50.1	-18.5
4 Ty Tanglwyst Farm	41.9	55.0	-13.1

Table 8.7 shows that the predicted noise levels for normal operations during the Phase 3 operations will be below the limits derived in accordance with the guidance contained in MTAN1 at all locations assessed.

Table 8-7 Predicted Noise Levels for Temporary Operations – Phase 3, free-field, dB

	Predicted Noise Level $L_{Aeq,1hr}$	Limit Daytime	Difference Daytime
1 Cornelius Close	41.5	67.0	-25.5
2 Rock Cottages	59.9	67.0	-7.1
3 Mount Pleasant Road	36.8	67.0	-30.2

4 Ty Tanglwyst Farm	43.0		-24.0

8.8.2 Site-related Road Traffic Movements

The site is currently operational and traffic movements of up to four HGV export movements per hour (based on 31 HGV export movements in a working day) occur. The number of HGV movements will remain the same as in current operations under the proposed scheme.

Four HGV exports per hour equates to 8 trips per hour (i.e. HGV arriving and leaving). It is understood that all HGV's would turn right on leaving the site and continue northwards towards the M4 except for a very small number of local deliveries.

The former Department of Transport document *Calculation of Road Traffic Noise* (CRTN, 1988) states that calculations of noise level for traffic flows below 50 vehicles per hour or 1000 vehicles per 18 hour day are unreliable and measurements should be taken when evaluating such cases.

An alternative method of assessing off site road traffic noise impacts is to utilise the haul route methodology contained in BS5228-1:2009 to predict road traffic noise levels and then logarithmically add these predicted road traffic noise levels to the measured ambient noise levels at the noise sensitive receptors.

However, as the site is currently operational, the noise generated by lorry movements will be included within the measured ambient noise levels.

As the traffic movements remain the same as the current scheme it is considered that a comparison between the predicted road traffic noise levels and the noise limits based on the background noise levels would be appropriate. Whilst this is not standard practice, it is considered to give a reasonable indication of the level at which off-site road traffic noise will impact local noise-sensitive receptors.

Traffic noise impacts will only be considered at Locations 1, 2 and 4 due to the route of the HGV's as they leave the quarry.

The table below (8.8) shows the predicted off-site road traffic noise level at Locations 1, 2 and 4:

Table 8-8 Predicted Noise Levels for off-site road traffic, free-field, dB

	Predicted Noise Level $L_{Aeq,1hr}$	Limit Daytime	Difference Daytime
1 Cornelius Close	53.5	55.0	-1.5
2 Rock Cottages	40.2	50.1	-7.9
4 Ty Tanglwyst Farm	45.8	55.0	-9.2

The predicted noise level due to off-site road traffic is below the daytime noise limit at all potentially affected locations. It is concluded that off-site road traffic noise impacts are likely to be negligible.

8.8.3 Combined effects

To ascertain the combined noise levels at local sensitive receptors due to operations at the site and off-site road traffic it is necessary to add the predicted noise levels for both activities.

Tables 8.9 to 8.11 below show the predicted combined noise levels expected at nearby noise-sensitive receptors for existing operations and for Phase 3 operations:

Table 8-9 Predicted combined Noise Levels, existing operations, free-field, dB

	Predicted combined Noise Level $L_{Aeq,1hr}$	Limit Daytime	Difference Daytime
1 Cornelius Close	53.7	55.0	-1.3
2 Rock Cottages	46.9	50.1	-3.2
3 Mount Pleasant Road	26.0	50.1	-24.1
4 Ty Tanglwyst Farm	46.8	55.0	-8.2

Table 8-10 Predicted combined Noise Levels, Phase 3, free-field, dB

	Predicted combined Noise Level $L_{Aeq,1hr}$	Limit Daytime	Difference Daytime
1 Cornelius Close	53.6	55.0	-1.4
2 Rock Cottages	49.9	50.1	-0.2
3 Mount Pleasant Road	31.6	50.1	-19.6
4 Ty Tanglwyst Farm	47.3	55.0	-5.8

Table 8-11 Predicted combined Noise Levels, Phase 3 temporary operations, free-field, dB

	Predicted combined Noise Level $L_{Aeq,1hr}$	Limit Daytime	Difference Daytime
1 Cornelius Close	53.8	67.0	-13.2
2 Rock Cottages	59.9		-7.1
3 Mount Pleasant Road	36.8		-30.2
4 Ty Tanglwyst Farm	47.6		-19.4

It can be seen from the above tables that predicted noise levels due to all operations on and off site are below the relevant daytime limits at all locations.

8.9 Cumulative effects

There is the potential for cumulative impacts as a result of quarrying operations in the area, which, in addition to Gaens Quarry, include the operational Cornelly Quarry, and the currently mothballed Grove Quarry, together forming the Cornelly Group of Quarries.

The cumulative noise levels at the common three receptors used due to operations taking place concurrently in Cornelly, Grove and Gaens Quarries are presented in the following tables. Table 8-12 presents the cumulative noise levels due to routine daytime operations and Table 8-13 displays the cumulative noise levels from temporary operations.

Table 8-12 Cornelly, Grove and Gaens Quarries Calculated Site Noise Levels

Routine Operations Daytime (07:00-19:00)

Location	Calculated Site Noise L_{AeqT}	Criterion $L_{Aeq,T}$
Rock Cottages, South Cornelly	55	55
Seaview, Mount Pleasant Road	50	55
Ty Tanglwyst Farm	52	55

Table 8-13 Cornelly, Grove and Gaens Quarries Calculated Site Noise Levels

Temporary Works Daytime (07:00-19:00)

Location	Calculated Site Noise $L_{Aeq,T}$	Criterion $L_{Aeq,T}$
Rock Cottages, South Cornelly	60	67
Seaview, Mount Pleasant Road	54	67
Ty Tanglwyst Farm	49	67

8.10 Mitigation Measures

8.10.1 Good Site Practice

Quarries by their nature generate noise due to the use of heavy machinery. During the continued development the potential risk of noise would vary according to the type of activity being undertaken at the time and the effectiveness of any noise control measures that are in place. The site design incorporates several features that provide mitigation against potential noise nuisance; most notably the screening effects of the quarry working faces between operations and noise-sensitive receptors.

In addition to the noise mitigation measures incorporated into the site design, good site management practices and other specific measures also provide additional noise mitigation.

These measures have been included within the design of the working phases and inlcude

- internal haul routes are routed such that separation distances to the noise sensitive properties is maximised;
- all haul roads are kept clean and maintained in a good state of repair to avoid unwanted rattle and "body slap" from vehicles;
- drop heights for all loading activities are minimised;
- all mobile plant used at the quarry has noise emission levels that comply with the limiting levels defined in EC Directive 86/662/EEC and any subsequent amendments;
- all mobile plant and heavy goods vehicles entering the site move in a manner to minimise, as far as is practical and safe, noise from reverse warning systems;
- plant is operated in a proper manner with respect to minimising noise emissions, for example, minimisation of drop heights and no un-necessary engine revving;
- plant is subject to regular maintenance. All plant at the site is fitted with effective exhaust silencers and is maintained in good working order to meet manufacturers' noise rating levels. Defective silencers are replaced immediately;
- plant that is used intermittently, is shut down when not in use; and

8.11 Specific Mitigation Measures and Potential Planning Conditions

Given that the predicted noise levels at local noise-sensitive receptors due to normal quarrying operations are within the relevant limits of MTAN1 it is considered that no further specific mitigation measures are necessary.

The schedule of proposed planning conditions includes reference to the MTAN1 criteria commonly employed in similar circumstances.

8.12 Conclusions

The assessment has considered the potential for operational noise to give rise to impacts at the closest noise-sensitive receptors to the quarry.

With the implementation of the recommended mitigation measures and constraints in Section 8.11 the assessment has found that:

- noise levels generated by current quarrying operations would meet the criteria derived in accordance with MTAN1 at all the locations assessed; and
- cumulative noise impacts from Gaens Quarry in combination with the current operations at Cornelly Quarry and Grove Quarry would meet the criteria derived in accordance with MTAN1 at all the locations assessed.

HGV movements associated with the development would have a negligible impact.

Based on the operational activities described, the strategic location of storage and screening mounds, routing of internal haul roads away from noise-sensitive receptor locations where possible and the application of mitigation measures, it is considered that the applicant has taken all practical steps to ensure that the operations meet with the requirements of MTAN1 with respect to noise at all locations.

9.0 BLAST VIBRATION

9.1 Introduction

A quantitative assessment has been carried out of the potential impact upon nearby receptors from blasting operations at the quarry. The chapter also proposes a range of measures which would be used to enable any identified impacts to be minimised and mitigated.

The extent of the survey has been guided by the requirements of the Scoping Opinion issued by the Welsh Government as set out in Appendix 1/1.

9.2 Government Advice, Standards and Good Practice

9.2.1 Minerals Technical Advice Note 1: Aggregates (MTAN1)

Minerals Technical Advice Note 1: Aggregates provides advice on planning controls and good practice to keep the effects of blasting at surface mineral workings to acceptable levels without imposing unreasonable burdens on mineral operators.

MTAN1 states, in paragraph 83, that:

"*Planning conditions relating to the control of blasting should only: relate to those aspects of environmental management that are under the control of the operator; should be directly relevant to environmental issues; and, should not be in conflict with existing health and safety legislation. Consequently, planning conditions should provide for the:*

- *acceptable days for blasting operations: unless there are exceptional circumstances such as a safety emergency, blasting should take place at regular times within the working week, that is, Mondays to Fridays. Blasting on Saturday mornings should be a matter for negotiation between the operator and the MPA taking into account the views of any nearby residents. No blasting should take place at any other time, that is, Saturday afternoons, Sundays, Bank or National holidays;*

- *acceptable times of blasting operations: blasting should only take place between the hours of 10.00am and 16.00pm, except when there is an emergency in the interests of safety;*

- *maximum level of ground vibration at vibration sensitive locations: ground vibration as a result of blasting operations should not exceed a peak particle velocity of 6 mms-1 ppv in 95% of all blasts measured over any 6 month period, and no individual blast should exceed a peak particle velocity of 10 mms-1 ppv;*

- *approval of a scheme by which air overpressure is managed and mitigated through careful design of blasting operations;*

- *approval of a scheme of vibration monitoring so that compliance within set limits can be adequately demonstrated by the operator at any time.*

The guidance set out in MTAN1 is directly applicable to the blasting operations proposed at the site.

9.2.2 British Standard 6472

British Standard 6472:2008 *Guide to evaluation of human exposure to vibration in buildings* Part 2: *Blast-induced vibration* gives guidance on human exposure to blast-induced vibration in buildings. It is primarily applicable to blasting associated with mineral extraction.

BS6472-2:2008 gives details of the maximum satisfactory magnitudes of vibration for residential properties which is shown in Table 9-1.

Table 9-1 Maximum satisfactory magnitudes of vibration with respect to human response for up to three blast vibration events per day

Place	Time		Satisfactory magnitude ppv mms-1
Residential	Daytime	08:00 to 18:00 hrs Monday to Friday 08:00 to 13:00 hrs Saturday	6.0 to 10.0

BS6472-2:2008 details a method of predicting vibration at nearby vibration-sensitive receptors from previously measured blasting events, such as test blasts, or historical blasting data gathered as part of a blast vibration monitoring scheme.

9.3 Assessment approach

The assessment considers the vibration levels generated by operations at the nearby vibration-sensitive receptors.

In order to predict the likely vibration magnitude, measurements were made of vibration levels at a number of locations during blasting operations at the quarry.

An assessment has been made of the potential impact of the proposals. Mitigation measures and/or scheme changes to offset potentially adverse environmental impacts have been identified.

9.4 Potential Impact

9.4.1 Ground Vibration

There is considerable practical and theoretical research that has been undertaken into the damage potential of blast induced ground vibration including research by Vibrock Limited[2].

Blast-induced vibration is impulsive in nature and a typical time history would be rapid build-up to a peak followed by a decay which might or might not involve several cycles of vibration. A typical blast consists of a number of boreholes into which are placed explosive charges. Each borehole is detonated individually by the use of a series of detonators each with differing millisecond delays. Blast-induced vibration is measured in terms of unfiltered time histories of three component particle velocities from which the peak values can be identified.

The detonation of explosives within a confined borehole generates stress (seismic) waves causing localised vibration, distortion or cracking. Such ground vibration is always generated, even by the most well designed blasts, and will radiate away from the blast source, attenuating as distance increases. The research has concluded that the maximum value of particle velocity in any stress wave is the parameter of significance and is generally termed peak particle velocity (ppv).

With experience and knowledge of the factors which influence ground vibration, such as blast type and design, site geology and receiving structure, the magnitude and significance of the blast induced waves can be accurately predicted at any location.
In general terms, a person will become aware of blast-induced vibration at levels of around 1.5mms^{-1}ppv although under some circumstances this can be as low as 0.5mms^{-1}ppv. However, people are very poor at determining relative magnitudes of vibration, for example, the difference between 4.0mms^{-1}ppv and 6.0mms^{-1}ppv is unlikely to be perceived by a person.

Vibration levels between 0.6mms^{-1}ppv and 50.0mms^{-1}ppv are routinely experienced in everyday life within a property and are considered wholly safe. It is apparent though, when similar levels are experienced through blasting operations, it is not unusual for such a level to give rise to subjective concern. Table 9-2 gives examples of vibration levels routinely generated in a property.

Table 9-2 Vibration Levels Generated by Everyday Activities

Activity	Vibration Level mms-1ppv
Walking, measured on a wooden floor	1.0 – 2.5
Door slam, measured on a wooden floor	2.0 – 5.0
Door slam, measured over the doorway	12.0 – 35.0
Foot stamps, measured on a wooden floor	5.0 – 50.0

With regard to physical damage to properties, extensive research has been carried out around the world, the most prominent being undertaken by the United States Bureau of Mines (USBM). Damage to a structure could occur if the dynamic stresses

[22] The Environmental effects of Production Blasting from Surface Mineral Workings, Vibrock, Published by The Stationery Office 1998 (ISBN 0-11-753412-9)

induced in a structure by vibration exceed the allowable design stress for the specific building material. Classifications of building damage range from very fine plaster cracking up to major cracking of structural elements. In particular, when defining damage to buildings, the following classifications are used:

- **Cosmetic or threshold** – the formation of hairline cracks or the growth of existing cracks in plaster, dry wall surfaces or mortar joints.
- **Minor** – the formation of large cracks or loosening or falling of plaster on dry wall surfaces, or cracks through bricks/concrete blocks.
- **Major or structural** – damage to structural elements of the building.

Studies by the USBM concluded that vibration levels in excess of $50mms^{-1}$ ppv are required to cause structural damage. The onset of cosmetic damage can be associated with lower vibration levels. Vibration levels between $19mms^{-1}$ppv and $50mms^{-1}$ppv for open pit blasting are generally considered safe in the UK. It should be noted that these limits are for the worst-case structure conditions and that they are independent of the number of blasting events and their durations. No damage has occurred in any of the published data at vibration levels of less than $12.7mms^{-1}$ppv.

9.4.2 Air Overpressure

Whenever blasting is carried out, energy is transmitted from the blast site in the form of airborne pressure waves in a wide range of frequencies, some of which will be above 20Hz, and hence perceptible to the human ear, but most are below the audible range. It is a combination of the sound and concussion that is known as air overpressure.

Any attenuation due to topography, either natural or man-made, between the blast and the receiver do not significantly reduce air overpressure levels due to the greater amount of energy transmitted in the inaudible frequency range.

Overpressure may vibrate buildings but actual damage caused by air overpressure is rare. Damage in the form of broken windows is possible but extremely unlikely at 140dB, more frequently the perception of vibration, and consequently complaints, are high-lighted by windows and loose ornaments rattling which is possible at 120dB.

Meteorological conditions, such as wind direction and velocity, cloud cover, humidity and temperature inversions, also influence the intensity of air overpressure levels at any given location.

9.4.3 Fly-rock

Fly-rock is the unexpected projection of material from the blast site to any area beyond the designated safety area. Fly-rock occurs when the amount of explosive energy is greater than that required to break the mass of rock between the blast position and the free face, the excess energy projects the rock debris beyond the safety area.

Due to improvements in blast design technology, fly-rock incidents are extremely rare.

9.5 Blast Induced Vibration-sensitive Receptors

Vibration predictions have been carried out to the nearby locations with approximate distances from the blasting location to the nearest property facade, namely:

Table 9-3 – Location of Sensitive Properties

Location Ref	Location	Distance from nearest working face
Location 1	Cornelius Close,	280m to the northwest;
Location 2	Land adjacent Rock Cottages	25m to the west;
Location 3	Mount Pleasant Road,	700m to the south/southeast;
Location 4	Ty Tanglwyst,	350m to the north;

BS6472-2:2008 states that in order to predict the likely vibration magnitude, a series of measurements at several locations should be taken from one or more trial blasts.

The peak particle velocity in the three translational axes has been measured and the maximum component of the vibration used for each measurement location. Scaled distance graphs have then been prepared. Measurements were taken at various locations in and near the quarry of a production blast on 18th November 2013. This data has been supplemented by data from blasting at Cornelly Quarry (taken from the EIA produced for the IDO Review).

The values have then been plotted against scaled distance on logarithmic scales, where scaled distance is the sum of the distance from the blast location to the receptor divided by the root of the maximum instantaneous charge weight, to give a blast regression line. The plot includes the 95% confidence limit and is shown in Figure 9.2.

The regression line plot in Figure 9.2 shows that the corresponding scaled distance value for a vibration criterion of 6.0mms^{-1}ppv at 95% confidence level is 25.9mkg$^{-1/2}$.

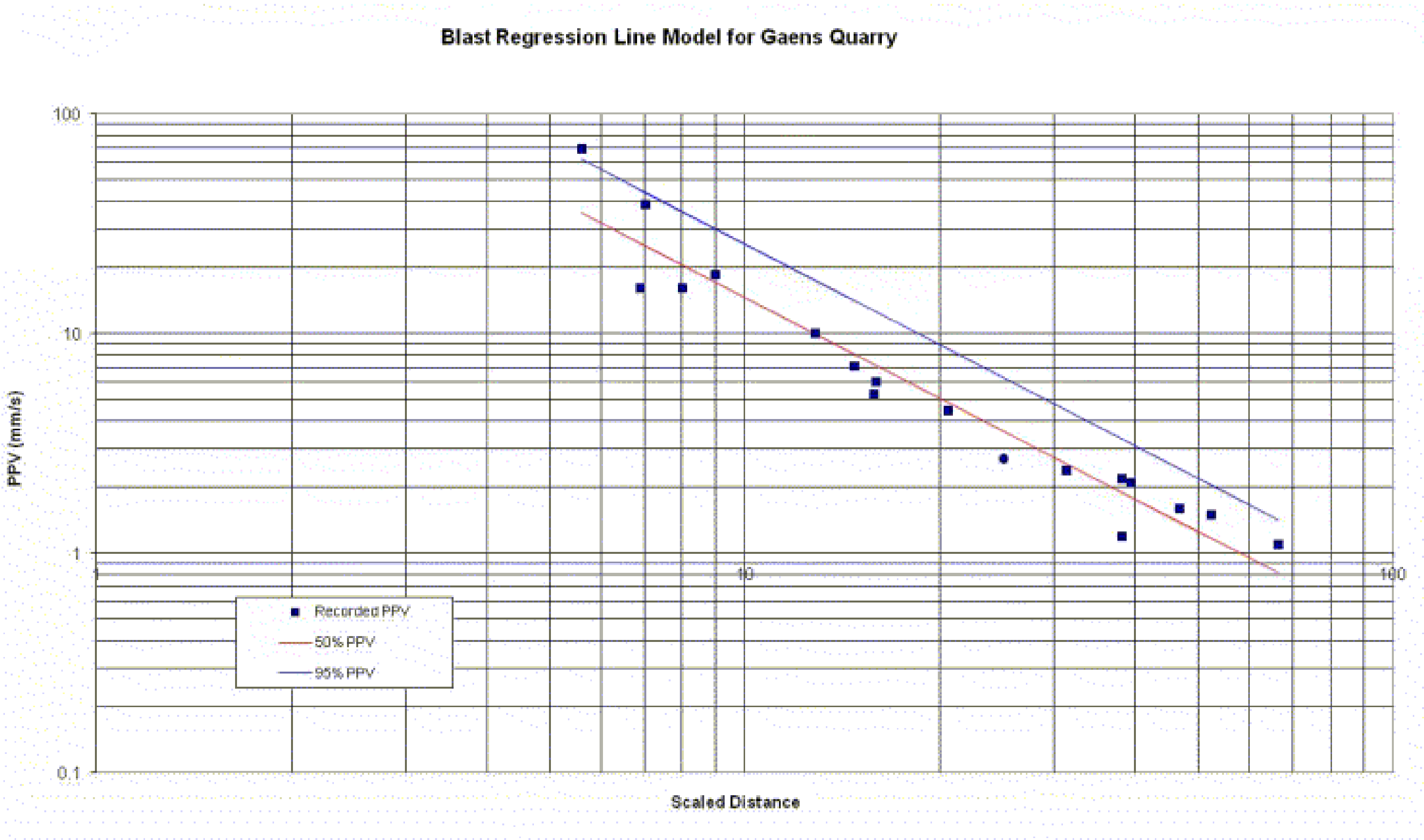


Figure 10-2 : Blast Regression Line Model for Gaens Quarry

9.6 Mitigation Measures

In terms of mitigation and planning conditions, the key requirement is to impose updated conditions which reflect the up to date advice set out in MTAN 1.

In this context, it is an established principle that specific aspects of blast design such as the number of boreholes or the amount of explosives used should not be included in the blasting conditions. Blasting design criteria must always be the direct responsibility of the site operator as defined by the Quarries Regulations 1999. Thus, conditions should state the desired objectives rather than the methods by which the objectives are to be achieved. In this case therefore the key issue is to set a limit on ground vibration, which will then require the Operators to design blasts to ensure adherence to the limits.

It follows that no specific prescriptive additional mitigation measures are considered to be necessary, since planning conditions are capable of regulating blasting in terms of timing, ground vibration limits etc. It is also important to recognise that blasting at Gaens Quarry is undertaken by qualified and experienced personnel where, in addition to planning controls, the operations are regulated by the Mines and Quarries Inspectorate.

Similar advice is set out in the DETR publication on the Environmental Effects of Production Blasting from Surface Mineral Workings, to the effect that planning conditions should focus on days and times for blasting operations; allowable ground vibration limits; a scheme for air over pressure control in preference to limit values, and a scheme of monitoring.

The opportunity is thus available via the ROMP Review application to impose updated conditions regulating blast vibration, which accord with modern standards and the advice set out in MTAN1.

The means of controlling ground vibration, air overpressure and fly-rock have many features in common. Many of these measures are required for safety reasons by the Quarries Regulations 1999 and the approved Code of Practice.

- correct blast design is essential and should include a survey of the face profile prior to design, ensuring appropriate burden to avoid over-confinement of charge which may increase vibration by a factor of two;

- the setting out and drilling of shot holes should be as accurate as possible and the drilled holes should be surveyed for deviation along their lengths and, if necessary, the blast design adjusted;

- correct charging is obviously vital, and if free poured bulk explosive is used, its rise during loading should be checked. This is especially important in fragmented ground to avoid accidental over charging;

- correct stemming will help control air overpressure and fly-rock and will also aid the control of ground vibration. Controlling the length of the stemming column is also important; too short and premature ejection occurs, too long and there can be excessive confinement and poor fragmentation. The length of the stemming column will depend on the diameter of the hole and the type of material being used; and

- monitoring of blasting and re-optimising the blast design in light of the results, changing conditions and experience should be carried out as standard.

10.0 AIR QUALITY

10.1 Introduction

This chapter considers the potential for the continuation of existing operations to impact upon air quality in the vicinity of the application site. The chapter describes the scope, relevant legislation, assessment methodology and the baseline conditions currently existing at the application site and its surroundings. It then considers any potential significant environmental effects the continuing operations would have on this baseline environment; the mitigation measures required to prevent, reduce or offset any significant adverse effects; and the likely residual effects after these measures have been employed.

The primary impacts from an air quality perspective in relation to site operation relate to the release of dust and traffic emissions and the potential exposure at sensitive receptors to these emissions. This chapter therefore specifically focuses on the potential of the site to generate dust and the potential impact of this dust on the environment. Dust is generally categorised into two size classifications; 'suspended dust' with diameters below 10µm (PM_{10}), and 'deposited dust' generally with diameters between 10µm and 75µm. The potential for any increase in vehicle numbers to have a significant effect on air quality is also considered within this assessment.

The assessment cross-refers to the environmental permitting regime under the Pollution Prevention and Control Act, which regulates the operation of the quarry processing plant and related activities, and which imposes controls on emissions and the monitoring of emissions from the plant, stockpiles, haul roads and aggregate handling operations[3].

Advice is set out in MTAN 1 which confirms that that controls imposed on a permit should not be duplicated as part of the planning regime (ref para 76).

However, as part of an EIA and the updating of planning conditions, it is appropriate to identify the main sources of dust at the quarry, and to consider whether it is necessary to include conditions relating to control measures to mitigate impacts where such measures are not specifically dealt with as part of a Permit. Detailed guidance on the control of dust at mineral working sites is set out in a DOE research project undertaken for the ODPM by Arup Environmental/OvE Arup and Partners on '*The Environmental Effects of Dust from Surface Mineral Workings*' (HMSO1995)[7]. The research project and its recommendations were extensively referenced in MPS2 'Controlling and Mitigating the Environmental Effects of Mineral Extraction in England Annex 1: Dust' (March 2005). MPS2 was cancelled in March 2012 by the National Planning Policy Framework for England (NPPF), but the practical guidance on planning conditions to control and minimise dust is considered to remain 'good practice' advice.

10.2 Scope

Gaens Quarry ROMP area is currently fully operational, extracting approximately 150,000 tonnes of limestone per annum. This assessment considers the impact of future operations, compared to the baseline scenario, it reviews existing mitigation measures and considers cumulative impacts.

---

[3] Environmental Permitting (England & Wales) Regulations 2010 (as amended) Permit No: 019/03 T S Rees Ltd Gaens Quarry November 2010

The ROMP boundary comprises the eastern side of Gaens Quarry, while immediately to the west of the review site is the former IDO quarry area and ancillary land that includes the quarry access, site office and weighbridge. Both areas have been considered within this assessment.

The scope of the assessment examines the current sources of dust emissions from the site and their impact of the continuation of quarrying on local receptors. Potential impacts at sensitive receptors in terms of exposure to dust emissions are assessed and appropriate measures are recommended where required.

The assessment takes account the comments made in the Scoping Direction provided by Welsh Government (dated 4/03/13) as part of the Town and County Planning (Environmental Impact Assessment) (Undetermined Reviews of Old Minerals Permissions) (Wales) Regulations 2009. These include:

- paragraph 14 which states: 'A dust assessment should be carried out to ascertain the likely effects of dust levels on the local population, flora and fauna, having regard to the advice on dust control set out in MTAN 1.';

- paragraph 15 which states: 'The ES must establish the baseline data to enable a thorough assessment of the impact of all future quarrying operation, including processing plant. The baseline data should relate to impacts from current areas of quarrying and also potential impact from proposed quarrying areas not presently being worked. The ES should refer to the detailed controls set out in the PPC Permit associated with the quarry plant and related activities, and the nature of any additional dust mitigation measures which should be imposed as part of the review of the planning conditions. The assessment should include cumulative impacts on other development.'; and

- aspects of paragraph 20 on Transport that state: 'The impacts of traffic (… dust, emissions and impact on local road network) arising from any increased extraction rates should be included'.

10.3 Legislation, Guidance and Industry Good Practice

10.3.1 Air Quality Strategy

The Government's policy on air quality within the UK is set out in the Air Quality Strategy for England, Scotland, Wales and Northern Ireland (AQS) July 2007[4]. The AQS sets out a framework for reducing hazards to health from air pollution and ensuring that international commitments are met in the UK.

The AQS set standards and objectives for ten priority pollutants. The standards set are for concentrations of pollutants in the atmosphere which can broadly be taken to achieve a certain level of environmental quality. Objectives are policy targets often expressed as maximum concentrations not to be exceeded either without exception or with a limited number of exceedences within a specified timescale.

Many of the objectives in the AQS are made statutory in Wales with the Air Quality (Wales) Regulations 2010[5] for the purpose of Local Air Quality Management (LAQM).

[4] The Air Quality Strategy for England, Scotland, Wales and Northern Ireland - Defra - July 2007

[5] The Air Quality Standards (Wales) Regulations 2010, 2010. No. 1344 (w.126)

The strategy objectives for the pollutants considered in this chapter are shown in Table 10-1.

Table 10-1: Relevant Air Quality Strategy Objectives (Wales)

Pollutant	Standard	Measured as	Allowable exceedences
Particles (PM_{10}) (gravimetric)	$40 \mu g/m^3$	Annual Mean	-
	$50 \mu g/m^3$	24 Hour Mean	35/year
Nitrogen Dioxide	$40 \mu g/m^3$	Annual Mean	-
	$200 \mu g/m^3$	1 Hour Mean	18/year

10.3.2 Planning Policy Wales (PPW) February 2014

PPW stresses that Planning Authorities should operate on the basis that the relevant pollution control regimes will be properly applied and enforced by other agencies and they should not seek to control through planning measures, matters that are the proper concern of the pollution control authority (ref para 13.10.2). This is of relevance to the Permit which is in place at the quarry which regulates emissions from the processing plant and related operations (as discussed further below). Similar advice is provided in MPG14 and MTAN1, as discussed in section 10.1 above.

However PPW continues by noting that where pollution considerations affect the use and development of land, then these may be material planning considerations. This provision extends to air quality objectives and the local authority's Air Quality Management Areas (ref para 13.10.3).

In considering planning applications, material considerations will include location, the risk and impact of potential pollution, insofar as this might have an effect on the use of other land and the surrounding environment, prevention of nuisance, impact on road networks, and restoration of the site to appropriate after uses (ref para 13.12.1). Whilst a ROMP Review is not a planning application, these issues are of relevance to an air quality study, and in assisting recommendations for dust / air quality planning conditions. Each of these issues are thus discussed further below.

10.3.3 Minerals Technical Advice Note 1: Aggregates

Minerals Technical Advice Note 1 (Wales) on Aggregates sets out detailed advice on the mechanisms for delivering the policy for aggregates extraction, by Mineral Planning Authorities and the aggregates industry.

MTAN 1 includes guidance to '*reduce the impact of aggregates production*' which includes dust. The Guidance describes the effects of dust (ref 'key principle C'). The Guidance describes the main sources of dust (para 72) and the main potential effects of dust and dust emissions (para 73). It continues by noting that "*Planning conditions can control certain activities to protect against dust emissions although many of these are controlled under the Environmental Protection Act 1990, and care should be taken to avoid duplication of controls...."*(ref para 76). Subject to this advice and the similar advice in MPPW, MTAN1 suggests that planning conditions can impose:

- an adequate and appropriate monitoring scheme of the environmental consequences of aggregates extraction- the means of which achieving the requirements should be left to the operator;
- ameliorative measures to mitigate impacts, such as provision of wheel-wash facilities, road cleansing, speed restrictions, sheeting of vehicles;
- working programmes/site design and layout: location of dust emission sources away from sensitive development, protection of loading/unloading activities and materials storage area, and control of soil handling and overburden stripping including timing to suit weather conditions.

This defines a buffer zone of 200m around hard rock quarries, within which *'no new sensitive development or mineral extraction should be approved'* within this area.

10.3.4 Local Planning Policy

Bridgend County Borough Council (BCBC) adopted their Local Development Plan (LDP) in September 2013. Policy EN11 of the LDP states:

> *'All mineral related developments … will be permitted only where all of the following criteria are satisfied:*
> *..Measures can be taken to reduce damage or disturbance to neighbouring land uses to acceptable levels including:*
> *a) The effects of excessive noise, dust or vibration arising from the methods of working set out in a health impact assessment; and*
> *b) The impact of traffic generated to and from the site.'*

10.3.5 The Mineral Industry Research Organisation (MIRO)

A 'Good Practice Guide' issued on behalf of MIRO was released in 2011[6]. The purpose of the Guide is to assist in the identification, control and management of dust arising from the extractive industries during:

- site design and preparation of planning applications;
- site opening and preparation (soil and overburden removal, handling and storage);
- quarrying for the extraction of minerals;
- extraction and mineral processing; and
- site restoration and closure.

The guidance provides a useful reference for available methods of mitigation and monitoring.

10.3.6 General Nuisance Legislation

Part III of the Environmental Protection Act (EPA) 1990 (as amended by the Noise and Statutory Nuisance Act 1993) contains the main legislation on Statutory Nuisance and allows local authorities and individuals to take action to prevent a statutory nuisance. Section 79 of the EPA defines as a potential Statutory Nuisance amongst other things, smoke, fumes, dust and smells emitted from industrial, trade or business premises so as to be prejudicial to health or a nuisance. It also defines as a nuisance accumulation or deposit which is prejudicial to health.

There are no statutory limit values for dust deposition above which 'nuisance' is deemed to exist – 'nuisance' is a subjective concept and its perception is highly dependent upon the existing conditions and the change which has occurred.

Dust deposition is not covered within the National Air Quality Strategy as it typically relates to nuisance effects as opposed to potential health effects. When the rate of accumulation of this coarser fraction of dust (referred to as deposited dust) is sufficiently rapid to cause fouling or discolouration then it is generally considered to introduce a nuisance. The point at which an individual perceives dust deposition as a nuisance and causes a complaint is highly subjective and

[6] Good practice guide: Control and measurement of nuisance dust and PM10 from the extractive industries. Report to The Mineral Industry Research Organisation (MIRO). February 2011. AEAT/ENV/R3140.

there are no statutory numerical limits that define at what level dust becomes a nuisance. However, a custom and practice limit of 200mg/m^2/day is often used as a guide at which the onset of nuisance might be experienced.

10.3.7 Design Manual for Roads and Bridges

The "Design Manual for Roads and Bridges" (DMRB)[7] was originally introduced in 1992 in England and Wales. It provides, via a series of updates a comprehensive manual system which accommodates current standards, advice notes and other published documents relating to trunk road works. In the UK, particularly in relation to air quality, the DMRB guidance is commonly applied to proposed schemes involving changes to traffic flows and also in LAQM Updating and Screening Assessments.

10.4 Assessment Approach

For the purposes of environmental assessment dust is generally categorised into two size classifications; 'suspended dust' with diameters below 10µm (PM_{10}), and 'deposited dust' with diameters between 10µm and 75µm. The impacts associated with deposited dust are related to potential nuisance effects, whilst for PM_{10} air quality standards exist. The approach for assessing the potential impacts of each fraction has been undertaken separately.

10.4.1 Suspended Dust

The assessment of suspended dust considers the activities on site with the potential to release or generate significant volumes of PM_{10}, the existing levels of PM_{10} in the local area, and the proximity of communities and other sensitive receptors. The potential for the operations to increase ambient particulate concentrations above the relevant AQS objectives is then assessed.

In terms of whether the PM_{10} concentration in the local area is likely to exceed the AQS standard, existing PM_{10} concentrations have been reviewed.

Representative baseline PM_{10} data has been sought from local authority monitoring data, Automatic Urban Rural Network (AURN) monitoring sites in proximity to the site, and estimated concentrations provided on 1km by 1km grid by Defra.

An approach is detailed within the Local Air Quality Management technical guidance LAQM.TG(09) (Box 5.10)[8] for a screening assessment of dust emissions from fugitive and uncontrolled sources. The initial phase of the assessment establishes whether there is relevant exposure "near" to the source(s) of emissions. Relevant exposure is identified as "near" as follows:

- 1000m for a background PM10 level >28 µg/m3;
- 400m for a background >26 µg/m3;
- 200m for any background; and
- 50m from off-site access roads where background PM10 concentrations are >25µg/m^3.

If there is relevant exposure, further assessment is required entailing an assessment of site contribution to background PM_{10} levels and comparison with AQS objectives.

[7] Highways Agency (2007) Design manual for roads and bridges. Version 207/07.

[8] DEFRA 2009. Local Air Quality Management. Technical Guidance LAQM.TG(09)

The distances used in this methodology are from the source of dust emissions which does not always coincide with the boundary of the site. If there is no relevant exposure near to the source, in accordance with LAQM.TG(09), there is considered no requirement to proceed further.

10.4.2 Deposited Dust

A semi-quantitative assessment of potential impact on amenity from the ongoing development has been undertaken. The assessment has been undertaken by constructing a conceptual model that takes into consideration the potential sources, surrounding receptors, and the pathway between source and receptor in order to assess the magnitude of risk

The distance from the source to the sensitive receptor is crucial. The vast majority of particles responsible for annoyance are deposited within 100m of the source[9], and hence it is in this zone that the risk of problems from dust is greatest.

To allow for this effect of distance, buffer zones are often defined by mineral and waste planning authorities around potentially dusty activities to ensure that sufficient protection is provided. The DoE Guidance[7] recommended a stand-off distance of 100-200m from significant dust sources (excluding short-term sources), although it is recognised that these distances can be reduced if effective mitigation measures are identified and implemented.

The initial risk screening stage (tier 1) focuses upon the potential for dust generation at the proposal site and the distance between source and receptors. In tier 1 of the assessment, dust sensitive receptors are identified within a radius of 1km from the application site.

Further assessment is considered to be required for those receptors within 500m of dust generating activities. This is considered to be a precautionary approach on the basis of the 200m stand-off given in the DoE guidance. Receptors within 500m of dust generating processes progress onto a tier 2 assessment.

Tier 2 involves identifying source-pathway-receptor linkages and a semi-quantitative assessment of the likelihood and magnitude of any effects that could be associated with each pollutant linkage. This assessment takes account of:

- wind direction and speed data (to estimate frequency of exposure);
- proximity to source (to estimate magnitude of exposure);
- sensitivity of receptor; and
- occurrence of natural dust suppression (rainfall patterns).

This information is used to inform a qualitative assessment of the likely magnitude of impact and is based upon professional experience of the assessor in quarry activities as the issue of dust nuisance on local receptors is a subjective issue, where public perception on what constitutes ‘acceptable’ levels varies from one person to the next. Assigning significance to nuisance impacts is qualitative and involves a judgement based on the likely magnitude, frequency, duration and reversibility (or recovery) of the impact. In this context, significant impact is taken to mean what is generally not publicly acceptable and desirable.

Following the results of the risk assessment additional mitigation measures are detailed if required and the residual impact assessed.

[9] Based upon DoE research document - Arup Environmental/OvE Arup and Partners on ‘The Environmental Effects of Dust from Surface Mineral Workings’ (HMSO1995) Dec 1995

The assessment methodology used within the assessment is described fully in Appendix 10/1.

10.4.3 Assessment of Traffic Emissions

Atmospheric emissions related to site proposals are primarily associated with the exhaust emissions from Heavy Goods Vehicles (HGV's). The decision as to whether an assessment of potential impact is required is based upon the criteria set out in the Design Manual for Roads and Bridges.

The criterion for assessment of air quality contained within the latest DMRB guidance[10] (207/07) focuses on roads with relatively high changes in flows or high proportion of heavy good vehicle (HGV) traffic. Affected roads are defined as those that meet any of the following criteria:

- road alignment will change by 5 m or more; or
- daily traffic flows will change by 1,000 AADT or more; or
- HGV flows will change by 200 AADT or more; or
- daily average speed will change by 10 km/hr or more; or
- peak hour speed will change by 20 km/hr or more.

None of these criteria apply to local highway network in respect of the ongoing operation at Gaens Quarry (ref Traffic Assessment Chapter 11.0).

10.4.4 Air Quality Significance Criteria

The Town and Country Planning (Environmental Impact Assessment) Regulations 2011 require '*a description of the likely significant effects of the development on the environment, which should cover the direct effects and any indirect, secondary, cumulative, short, medium and long-term, permanent and temporary, positive and negative effects of the development*'. This has resulted in the use of *descriptors* for the purposes of summarising impacts. The assessment of significance for dust impacts is undertaken qualitatively and the criteria applied can be 'Insignificant', 'Adverse' or 'Beneficial'. The magnitude will be judged as 'Slight', 'Moderate', 'Substantial', or 'Very Substantial'.

10.5 Baseline Conditions

10.5.1 Existing Air Quality

Local Review and Assessment of Air Quality

The application site is situated within the administrative area of Bridgend County Borough Council (BCBC). The Council is required to review and assess their air quality under the Environment Act 1995 of which the most recent report available is the 2013 progress report.

There are no Air Quality Management Areas (AQMA's) declared within BCBC. Automatic monitoring for NO_2 and PM_{10} is undertaken by the council. The closest automatic monitor to the site is a PM_{10} monitor located within South Cornelly at the entrance to Gaens Quarry approximately 100m from the site boundary at its closest point, as displayed in Drawing AQ1 (Appendix 10/2).

A monitoring site for PM_{10} and NO_2 is located at Ewenny Cross Roundabout which is 7km from the site. Data capture for PM_{10} for the site was low at 25%. Results for both monitors are displayed in Table 10-2 below.

[10] Design Manual for Roads and Bridges. Volume 11 Section 3 HA207/02 Air Quality. May 2007

Table 10-2: PM_{10} Results

Year	PM_{10}				Nitrogen Dioxide
	South Cornelly		Ewenny Cross Roundabout		
	Annual Mean (µg/m^3)	Number of 24hr exceedances	Annual Mean (µg/m^3)	Number of 24hr exceedances	Annual Mean (µg/m^3)
2011	18.2[(a)]	0	-	-	18.8
2012	23.5	0	12.14	0	26.6

(a) Data provided by BCBC Public Protection Department. Period 8th April- 3rd June 2011

Ewenny Cross Roundabout is a significant distance from the quarry (approx. 7.3 km) and is not considered to represent baseline levels at the site. BCBC also undertakes diffusion tube monitoring at a number of locations, however similarly as none of these are close to the review site, they are not considered representative of baseline conditions. South Connelly is considered representative of baseline conditions due to the distance of the monitor from site and its proximity to quarrying operations (at Cornelly and Gaens Quarry). The values include the contribution of the existing Gaens Quarry operations and are 'well below'[11] the PM_{10} annual mean air quality limit of 40µg/m^3.

Defra Air Quality Background Maps

Defra provides background values for concentrations on a 1km x 1km resolution based upon 2010 values and projected forward. They also provide a breakdown of the relative contributions of various sources for PM_{10}.

The background PM_{10} concentration for the area of the site is based on 282500,180500, the 1km grid square that includes the site. These background values are presented below in Table 10-3.

Table 10-3: PM_{10} Background Concentrations

Parameter	2014
Total PM_{10}	14.6
Motorway	0.0
Trunk A Rd	0.0
Primary A Rd	0.03
Minor Rd	0.01
Brake & Tyre	0.04
Road Abrasion	0.02
Industry	1.05
Domestic	0.06
Rail	0.0
Other	0.03
PM secondary	4.86
Residual & Salt	7.11
Point Sources	0.24

[11] In accordance with *EPUK Guidance Development Control: Planning for Air Quality (2010 update),* 'well below' describes concentrations <75% of the AQS objective

From Table 10-3 it can be seen that existing air quality in terms of PM_{10} is considered to be good, with concentrations 'well below' the annual objective of 40µg/m^3.

The average nitrogen dioxide concentrations for the grid squares containing the site are displayed below. These concentration are also 'well below' the annual objective of 40µg/m^3 for nitrogen dioxide.

Table 10-4: Background NO_2 Concentrations

Pollutant	2014
NO_2	12.48

Council Deposited Dust Monitoring

BCBC undertaken deposited dust monitoring around the site for a number of years using Frisbee gauges and glass slides.

Frisbee Gauge Monitoring

Deposited dust monitoring using Frisbee Gauges is undertaken at 5 locations within the Borough. The closest to the site is Porthcawl Road Gauge, which has monitored intermittently since March 2008.

Table 10-5: Deposited Dust Results (mg/m^2/day)

	Average	Maximum
2008	68	184
2009	27	78
2010 (6 months)	19.5	25
2012 (2 months)	574	1091

Data Capture for 2010 and 2012 is very poor with 6 months and 2 months measured respectively. A custom and practice limit of 200mg/m^2/day has been applied, despite the council applying an 80mg/m^2/day (as recommended in MTAN2:Coal) which is not applicable to this site as limestone rather than coal is quarried. Of the periods monitored average deposited dust was found to be below the custom and practice level of 200mg/m^2/day. The maximum result of 1091mg/m^2/day was recorded 22/08/12 to 04/10/12, where the majority of material comprised sand at 897mg/m^2/day followed by amorphous dirt at 174.56mg/m^2/day. There was no calcium rich fragment (indicative of limestone dust) in the sample. No further monitoring was undertaken after this high result. No further information is available and therefore it is not possible to comment on the source.

Glass Slide Monitoring

Deposited Dust monitoring using glass slides has been monitored at locations within South Cornelly since 2006. The custom and practice limit applied to glass slide results is 25 Soiling Units (SU) per week, while the council have adopted a 20 SU '*unacceptable*' threshold. The results for this period are displayed in the table below:

Table 10-6: Glass slide Results 2006-2012 (SU)

	Trading Estate	Rear of trading estate	Hawthorn Drive	Greenacres	Adjacent to Gaens	Cornelius CLose	Off Porthcawl Road	Cornelius close	Clevis Court	Adjacent to Gaens
Average	9.6	9.8	7.7	9.7	11.2	14.9	9.7	10.4	7.7	8.9

Max	37.8	46.5	61.4	34.0	54.7	48.5	33.6	48.0	18.5	35.5
No>20	21	17	14	22	18	53	17	18	0	6
No>25	8	5	5	9	10	32	10	4	0	3

The most recently available results for 2010 to May 2012 have been analysed, as these are considered to reflect more current activities.

Table 10-7: Glass Slide Results for 2010-2012 (SU)

	Tradin g Estate	Rear of trading estate	Hawthorn Drive	Greena cres	Adjacent to Gaens	Cornelius Close	Off Porthcawl Road	Cornelius close	Adjacent to Gaens
Average	11.5	9.6	8.1	8.8	12.1	12.8	9.5	11.6	8.9
Max	37.8	26.6(a)	61.4	27.8	54.7	48.1	32.0	42.4	35.5
No>25	6	3	3	3	7	4	4	2	3
No<25	75	85	92	95	97	94	92	101	70

(a) Maximum of 44.9SU was measured over a 2 week period and therefore the highest 1 week exposure has been presented.

Table 10-7 shows that the majority of weekly results are less than <25 SU. The majority of the highest results were recorded during the period 06/02/2012-05/04/2012. It can be seen that locations 'adjacent to Gaens' and the Trading Estate were above the limit more often than other locations within South Cornelly. The sources of dust closest to these locations are Bracey Concrete batching plant and Gaens Quarry.

Site Deposited Dust Monitoring Data

Deposited dust monitoring has been undertaken onsite to determine the baseline dust levels. Dust deposition monitoring has undertaken using Method N˚ FD01: The Determination of Fugitive Dust and dust soiling using Method N˚ FD05: the Measurement of Reflectance by Smoke Stain Reflectometer. Three Frisbee gauges have been positioned around the perimeter of the site to determine deposited dust levels and direction of dust flux. The location of the deposited dust gauges are displayed in drawing AQ-1 and a description within Table 10-8.

Table 10-8: Frisbee Gauge Location

Monitor Reference	Location Description
FG1	Adjacent to the haul road at the entrance to the site, close to the site offices
FG2	At the south eastern corner of the site, adjacent to extraction area
FG3	At the north east corner of the site adjacent to the extraction area, within prevailing wind direction

Monitoring is due to be undertaken for 8 months, with monitoring commenced on 6th November 2013.

Table 10-9: Onsite Dust Deposition Results (mg/m^2/day)

Date	FG1	FG2	FG3
06/11/13-06/12/13	19	10	12
06/12/13–06/01/14	32	29	26
06/01/14-06/02/14	15	24	16
06/02/14-06/03/14	15	15	21
06/03/14-07/04/14	46	17	31
07/04/14-07/05/14	101	27	39

The dust deposition results to date show levels are well below the custom and practice limit of 200mg/m^2/day for dust deposition.

Table 10-10: Onsite Surface Soiling Results (%EAC/day) 06/11/2013-06/12/2013

Date	FG1		FG2		FG3	
	Avg	Max	Avg	Max	Avg	Max
06/11/13-06/12/13	0.1	0.1	0.1	0.2	0.0	0.0
06/12/13–06/01/14	0.0	0.0	0.1	0.1	0.0	0.1
06/01/14-06/02/14	0.1	0.1	0.2	0.5	0.1	0.1
06/02/14-06/03/14	0.1	0.1	0.1	0.2	0.1	0.1
06/03/14-07/04/14	0.1	0.1	0.1	0.2	0.0	0.1
07/04/14-07/05/14	0.1	0.1	0.1	0.2	0.0	0.1

The majority of surface soiling results are at or below the level for 'noticeable'[12] of 0.2%EAC/day. The results do not show a flux of dust from the direction of quarrying operations with the exception of FG2 during January which shows a flux of dust from the NE/E potentially in the direction of the quarry at a maximum level of 0.5%EAC/day for 'possible complaint', however dust deposition for this location are well below the limit.

Complaints Data

There have been a number of complaints relating to dust within South Cornelly due to operations at Gaens and Cornelly Quarry and Braceys Concrete Products. Six complaints received have been attributable to Gaens Quarry during the period 2009-2013. Details of these complaints are within Table 10-11 below:

Table 10-11: Complaints Data

Date	Complaint	Location	Investigation	Outcome
31/03/2009	Dust Nuisance	Ty Draw Lane	The investigation into the complaint found earthworks onsite, moving material onto the embankment, creating a large pile, which was allowed to dry out which resulted in dust emissions.	Enforcement action to lower the stock pile was taken
15/04/2009	Mud on Road	Clevis Court, Cornelius Close and Ty Draw Lane	Haul road widening to allow passing of two vehicles, to reduce mud on the road, meant wheel wash couldn't be used resulting in trackout of mud	Site instructed to sweep haul roads more frequency during the widening works
11/05/2009	Mud/ pooling of water on road	Railway Terrace	Site used the water bowser on the public highway	Site instructed not to use water bowser on public highway
04/11/2009	Dust Nuisance	Porthcawl Road	The complainants property was included in dust monitoring slide survey	Results shows levels >25SU on 4 occasions
06/03/2013	Dust Nuisance	Greenacres	Investigation showed regional dust levels were generally high, however	Permit inspection did not identify an

[12] Beaman, A. L. and Kingsbury, R. W. S. M. (1981) "Assessment of Nuisance from Deposited Particulates using a Simple and Inexpensive Measuring System ", Clean Air, 11(2), 1981, pp77 – 81

0.2%EAC/day 'noticeable'; 0.5%EAC/day 'Possible complaint'; 0.7%EAC/day 'Objectionable'; 2.0%EAC/day Probable Complaint; and 5.0%EAC/day Serious Complaint

			sample of dust at property showed the presence of limestone dust, potentially from local influence	obvious source of dust
01/10/2013	Dust Nuisance	Greenacres	Sample of dust confirmed the presence of limestone. Gaens Quarry the most likely source of dust	A later permit inspection did not identify an obvious sources of dust

There was one additional dust complaints during the period 2009-2013 which was attributable to Cornelly Quarry.

10.5.2 Meteorology – Dispersion of Emissions

Local Wind Speed and Direction Data

A windrose for the average conditions recorded at Mumbles, located 21km from the site over a five year period is presented below in Figure 10-1:

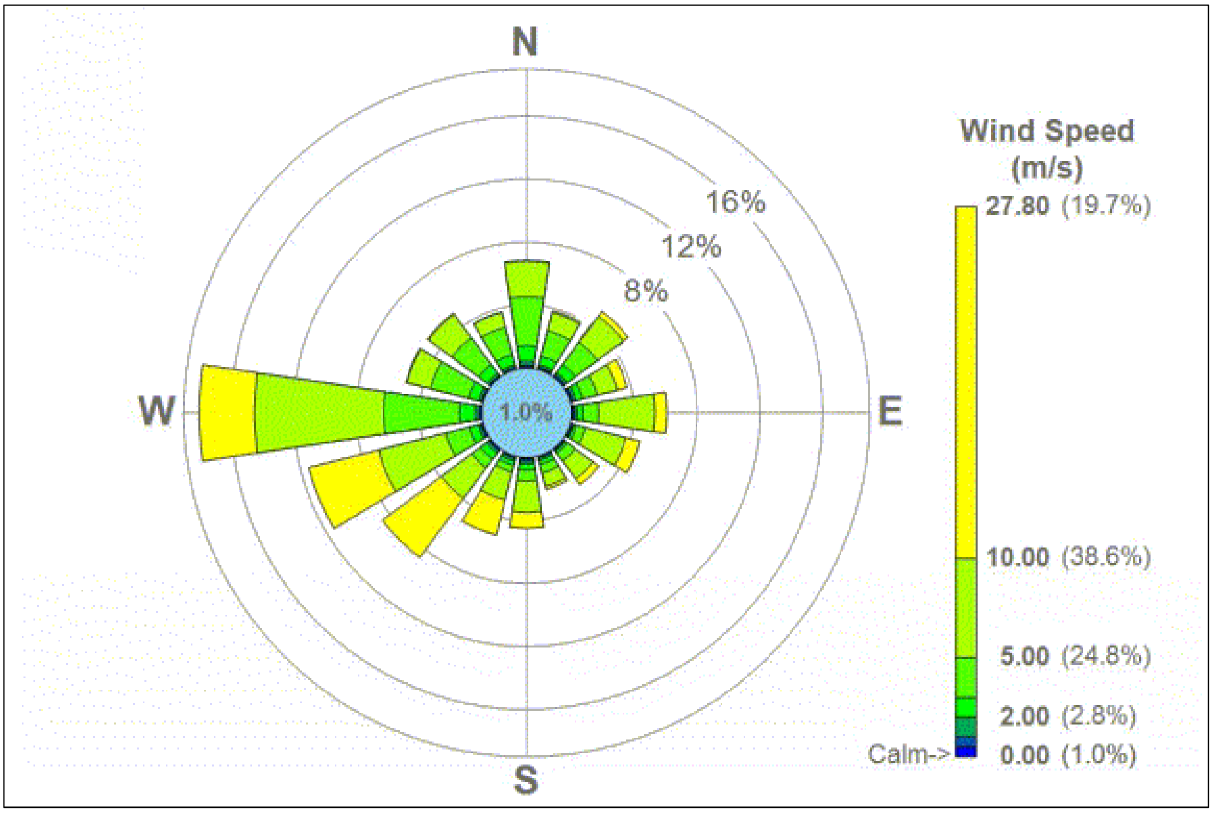


Figure 11-10-1 Windrose for Mumbles Meteorological Station

10.5.3 Rainfall Data

Relevant rainfall data applicable to the site has been obtained from the Meteorological Office website of UK mapped climate averages for 1981-2010. The average annual rainfall >0.2mm/day for the area of the site is 180-200 days per year, comprising 49% of the year.

10.6 Dust Sensitive Receptors

10.6.1 Human Receptors

Sensitive locations are those where the public may be exposed to dust from the review site. Types of location with a high sensitivity to dust include hospitals and clinics, hi-tech industries, painting and furnishing and food processing. Locations classed as being moderately sensitive include schools, residential areas and food retailers, and those considered to be low sensitivity include farms[13].

There are a number of isolated properties surrounding Gaens Quarry review site, with the nearest community being South Cornelly adjacent to the site to the west. Receptors have been identified as those closest to the site in each direction for the purposes of assessing risk and therefore this list is not exhaustive.

The distances and directions of identified receptors within 1km of the review site are detailed in Table 11 -12 and are illustrated in Drawing AQ-1 (Appendix 10/2).

Table 10-12: Identified Sensitive Receptors

Ref No.	Receptor	Sensitivity	Easting/Northing	Distance from Site Boundary (m)	Distance from ROMP Boundary (m)	Direction from Nearest Site Boundary (°)
1	Mount Pleasant Farm	Medium	283306,179580	836	836	140
2	Seaview	Medium	282742,179562	626	626	160
3	Cornelius Close	Medium	281905,180570	135	273	260
4	Ballas Cottage	Medium	283396,180762	761	761	070
5	Ty Tanglwyst Farm	Medium	282299,180812	85	342	020
6	Hawtorn Drive	Medium	281938,180447	137	199	270
7	Clevis Court	Medium	282020,180572	27	180	290
8	Queen Street	Medium	282147,180323	57	57	270
9	Rock Cottages	Medium	282124,180455	24	26	280
10	Grove Farm	Medium	282127,179715	604	604	200
11	Cornelly Industrial Estate	High	282138,180217	155	155	230
12	Dan-y-graig Farm	Medium	281958,179910	509	509	220
13	South Cornelly Nursing Home	High	282016,180345	161	161	260
14	Maesgwyn	Medium	281796,181117	382	730	330

10.6.2 Ecological Receptors

Internationally and nationally designated ecological receptors have been identified in proximity to the review site as well as sites of local importance. Sites have been identified within 2km from the site.

Table 10-13: Identified Ecological Receptors

Site	Designations	Distance to Site
Cybffig/ Kenfig	SAC/ NNR/SSSI	1700m
Stormy Down	SSSI/SINC	1800m

[13] Communities and Local Government. Technical Guidance to the National Planning Policy Framework. March 2012.

Pany-y-hyl & The Beacons	SINCS	850m
Cornelly Quarry, Line Kiln Woods & Old Ballas Wood	SINCs	0m
Glaswelltiroedd Cefn Cribwr / Cefn Cribwr Penycastell, Cefn Cribwr Grasslands	SAC/SSSI	1800m
Merthyr Mawr/ Cybffig/ Kenfig	SAC/NNR/SSSI	3400m

Merthyr Mawr SAC/SSSI has also been included due to references within the Scoping Opinion

10.7 Assessment of Effects and Significance

10.7.1 Vehicle Emissions

Vehicles mainly access the site from Porthcawl Road and its roundabout junction with the A4229. It is anticipated that the nature of operations and the rate of extraction will not materially change and therefore the number of traffic movements is not expected to increase above existing traffic movements which are currently circa 50 HGV movements per day. Even with a slight variation in number of movements this will not exceed the DMRB screening criteria of 200 movements per day. Speed and road alignment are not considered to change as a result of continuing operations. Therefore as none of the roads in the network meet any of the DMRB screening criteria, the impact of the scheme can be considered to be 'neutral' in terms of local air quality and no further air quality assessment is required.

However in order to address the comments within the Scoping Direction further assessment of emissions from HGV's has been undertaken within Appendix 6-2. This shows current emissions have a 'negligible' impact in accordance with EPUK guidance[9].

10.8 Sources of Dust

The activities on site and their potential to generate dust emissions in the absence of mitigation measures are presented in Table 10-14. Operations at the site are controlled through the sites Environmental Permit[2], issued by Bridgend County Borough Council.

Operations of the site are on-going, which involve the following activities:

- extraction of limestone through blasting;
- transfer of material within the site;
- material processing; and
- progressive restoration.

Table 10-14: Potential Dust Sources

Activity	Potential for Dust Generation	Location
Excavation	Moderate	Within extraction areas
Blasting	Moderate	Excavation area
Transport – access road	Moderate	Access road & local road network
Transport – internal haulage routes	High	Haulage routes

Activity	Potential for Dust Generation	Location
Processing	Moderate	Mobile Plant located within Quarry
Soil and Overburden Removal	Moderate- High	South-eastern side of quarry
Storage	Low	Adjacent to processing plant and south side of site
Material Handling & Restoration	Moderate - High	Extraction area & tip area

The vast majority of particles responsible for annoyance are deposited within 100m – 200m of the source[14], and hence it is in this zone that the risk of problems from dust is greatest. Coarse dusts (for example greater than 30µm in diameter) will largely deposit within 100m of the source.

For all sources, the creation and subsequent dispersion of dust will be highly dependent on the weather conditions. Wind speed can determine the amount of dust raised, while wind direction determines those areas that may be affected. Higher wind speed increases the potential for the generation of airborne dust due to the suspension and entrainment of particles in airflow; rainfall however, has a suppressive effect on the generation of dust.

The amount of dust generated by each activity thus depends on the size of particles and, crucially, upon their moisture content. The principal activities that would give rise to potential for dust emissions from the development have been identified and are considered in turn below.

It should be emphasised that the activities which are described relate to the potential for dust emissions in the absence of mitigation measures. The potential is then assessed in terms of the risk of impact (section 10.9), followed by a consideration of the need for mitigation measures (section 10.10).

10.8.1 Excavation and Transfer of Limestone

Excavation at Gaens Quarry is on-going and involves blasting and removal of material by rubber tyred hydraulic loading shovels at a rate of 150,000 tonnes per year. As described in Chapter 3.0, excavation of the quarry will involve deepening of the quarry to -20m AOD within 4 phases. Firstly moving south before proceeding to the west of the site before finally working the far eastern side of the quarry.

Blasted material is handled by loaders into dump trucks for internal haulage to the crushing and screening plant. Generally coarse blocks of limestone are produced and therefore the risk of dust generation through handling of material by loaders is considered to be low (ref MIRO). The risk can increase during high wind speeds, but extraction is undertaken below the height of the surrounding land level and therefore the working face provides a physical barrier to dust movement, by reducing wind speeds and encouraging deposition. The extraction of limestone is on-going and therefore the magnitude of dust generation are not considered to materially alter or increase, provided production rate does not change. Dust generation could actually reduce as the depth of working increases, due to greater protection from the wind and increased vertical distance to receptors.

[14] Based upon research document - DETR, The Environmental Effects of Dust from Surface Mineral Workings (Dec 1995)

10.8.2 Blasting

Material is fragmented by blasting involving the drilling of a series of holes and filling with explosives. According to MIRO[15] the sources of dust from drill rigs used for drilling holes for the placement of explosives is high. Blasting itself however is considered to have a low emissions potential if properly designed and controlled and if coarse material is generated, and each blast is a single incident of very short duration. Emissions that are significant but short-lived emissions are likely to occur.

Overall there is considered to be a moderate potential of dust generation due to the intermittent nature of drill rig use. Blasting is currently undertaken onsite and as the extraction rate is not proposed to change the source of dust is considered to remain unchanged. However as noted above dust generation could reduce as the depth of working increases, due to greater protection from the wind.

10.8.3 Processing Plant Area

Excavated rock from the quarry face is transported by dump truck to a mobile crusher. Operation of the plant is controlled through an Environmental Permit, Permit Number 019/03 issued by Bridgend CBC.

As described in Chapter 3.0 material is crushed and then subsequently screened into different grades of material into stockpiles. Subsequently material is loaded into lorries for transport offsite.

The crushing and screening and subsequent handling of rock has the potential to disaggregate particles and therefore has the potential for moderate dust generation. As stated in Process Guidance Note 3/16 (12), *'It is unlikely that screens give rise to significant quantities of airborne dust as the top screen handles larger material and the lower screens handling the finer material are enclosed.'*

The overall emissions from the plant are considered to be moderate. The processing operations are not considered to change and therefore the magnitude of emissions are not considered to increase above the baseline. The movement of the location of the plant within the base of the mineral void will reduce the potential for dust movement across the site boundary due to the physical barrier.

10.8.4 Soil and Overburden Removal

Soil and overburden removal will be undertaken to the south east of the quarry, further away from receptors within South Cornelly. Typically the potential for dust emissions from soil and overburden removal is significant[13] but temporary and would vary considerably from day to day, depending on the level of activity, the specific operation, the location of the activity and the prevailing meteorological conditions.

During dry and windy meteorological conditions these intermittent yet intensive operations have an increased potential for dust generation in working areas of drier top soil. Therefore there is the potential for short-term moderate to high levels of dust emissions in the absence of mitigation measures.

---

[15] The Mineral Research Organisation (MIRO) Good Practice Guide: control and measurement of nuisance dust and PM_{10} from extractive industries.

10.8.5 Material Storage

Stockpiles are located within the site for the temporary storage of product. These are located adjacent to the processing plant and stockpiles located to the south of the site.

The potential for dust emissions from storage of product results from several distinct components of the storage process, including the loading / unloading of material, vehicle movement in the storage/tip area and wind erosion of surfaces and ground around the piles.

Loading and unloading of the storage piles has the potential for significant dust emissions but strongly depends on the timing of operations with respect to meteorological conditions and the characteristics of the material being handled. Operations carried out during periods of dry and windy weather are more likely to carry the dust beyond the site boundary. Dust could be generated by vehicles tracking over the base of the pile and wind whip, where material has been allowed to dry out.

The emissions from the piles depend on the age of the pile, the moisture content and the proportion of fines. Product storage piles are likely to continually be in use with new product added and removed from site. In accordance with MIRO the potential of dust emissions from storage within the quarry void are anticipated to be moderate as it is anticipated that material will be removed from site relatively quickly, but with graded material potentially including small particle sizes.

Material is already stored onsite and therefore the magnitude of dust emissions will remain unchanged. There is a large swath of woodland to the west of the quarry which will shield stockpiles from the wind as well as being located within the mineral void.

10.8.6 Transport: Internal movement

As described above raw material and product will be transported within the quarry. The majority of transport will be undertaken using dump trucks and loading shovel on unpaved haul roads made of compacted material.

Transport of material within Gaens Quarry has the potential to generate significant dust emissions. The emissions from unpaved haul roads are dependent on the weight, speed and number of wheels in contact with the road surface. Particulate emissions from unpaved roads have been found to be higher at greater vehicular speeds[16] and greater vehicle weight[17].

Particulate emissions from road surfaces are primarily due to re-suspension of loose material present on the road surface and the additional deposition of material from the under carriage of passing vehicles. Emissions may increase as a result of erosion of the haul road surface.

In addition to the generation of dust from the passage of vehicles, any loose dust across the road surface can also become entrained in wind blow, with the level of dust generation affected by wind speed, the condition of the surface and the size of dust particles.

Internal unpaved haul roads have a high potential for dust generation. The overall potential dust generation from internal vehicle movements is considered to be high, in accordance with MIRO

[16] Williams, D.S et al;., 2008. Particulate matter emissions by a vehicle running on unpaved roads. Atmospheric Environment (2008), doi:10.1016/j.atmosenv.2008.02.003

[17] Gillies, J.A et al. (2004) Effect of Road Vehicle Characteristics on unpaved road dust emissions. Atmospheric Environment (2005) doi:10.1016/j.atmosenv.2004.05.064

guidance. The number of internal vehicle movements are not expected to increase and therefore dust emissions are considered to remain the same.

10.8.7 Transport: Access Roads

Access to Gaens Quarry will remain as per the existing arrangements. The quarry is accessed from Porthcawl Road within South Cornelly, to the A4229. The access roads do not enter the review site. The existing potential for dust emissions from paved road surfaces are significantly less when compared to unpaved surfaces due to the fact that the road base does not erode. The main factor in the production of dust emissions is the re-suspension of loose material on the surface deposited by vehicles through spillages or trackout[18]. As with unpaved roads, in addition to the generation of dust from the passage of vehicles, any loose dust across the road surface can also become entrained by wind blow, with the level of dust generation depending on wind speed, rainfall and the size of dust particles.

The number of HDV movements as a result of operations within the review site is anticipated to remain generally unchanged from existing operations.

10.8.8 Restoration

Restoration of the site would involve allowing the excavation to fill with water to form a water feature, with progressive restoration of the upper quarry faces. These will be over-tipped with soil forming materials, and planted or allowed to regenerate naturally, to establish a range of woodland, scrub and grassland habitats. Within the processing area soils will be placed to enable the establishment of woodland or grassland.

This gradual restoration would restrict the amount of dust available to become airborne during soil moving. The potential for dust emissions from soil handling is significant[13] but temporary and would vary considerably from day to day, depending on the level of activity, the specific operation, the location of the activity and the prevailing meteorological conditions.

During dry and windy meteorological conditions these intermittent yet intensive operations have an increased potential for dust generation, particularly if soils are allowed to dry out. Some soil placement is within the excavation and therefore the working face will provide a barrier to dust entrainment. Such activities would be intermittent in nature so over the duration of the activities there is the potential for short-term moderate to high levels of dust emissions in the absence of mitigation measures.

10.9 Risk of Impacts

10.9.1 Suspended Dust

As there are receptors located within 1km of the application site, further assessment has been undertaken to investigate the likelihood of the AQS objectives being exceeded during the quarry operations.

The existing air quality in terms of annual PM_{10} has been assumed to be represented by BCBC's automatic monitor located within South Cornelly. Although data for just over one year is available, compared to predicted Defra background maps this is considered to represent a worse case baseline.

[18] USEPA 2011. AP42 Fifth Edition. Volume 1. Chapter 13. Miscellaneous Sources. Section 13.2.1

The background PM_{10} concentration recorded for 2012 is 23.5µg/m^3 which are 'well below' the limit. In accordance with LAQM.TG(09) considering the existing background levels and the proximity of receptors within 200m of the potential dust source, there is considered to be relevant exposure 'near' to the sources of dust emissions.

The baseline concentrations are considered to be representative of quarrying activates within the area due to being adjacent to operations. Current operations at Gaens quarry are already included within the baseline, and a continuation of quarrying operations at Gaens Quarry are not considered to lead to a significant increase in PM_{10} emissions.

10.9.2 Deposited Dust

Tier 1 Screening

The majority of receptors identified are located within 500m of the review site boundary. These receptors require further assessment and therefore progress onto Tier 2 of the assessment. Those receptors not within 500m of the development footprint are assessed as currently at an insignificant risk of impact. All other receptors have been considered in Tier 2.

Tier 2 Assessment

The assessment methodology is summarised in Appendix 10/1, which describes the frequency of exposure criterion and risk classification; the distance to source criterion and risk classification; and the risk evaluation ranging from insignificant to acceptable to further assessment / mitigation required. The assessment methodology does not take into account the baseline situation and assumes no existing site operations and mitigation measures. In addition, the distance used for the assessment is that to the closest point to the ROMP review site boundary rather than to the source of the dust generating activity, and in many cases the dust generating activities will be at a greater distance to the distances assessed.

Table 10-15: Tier 2 Assessment of Impacts Gaens Quarry

Receptor Name (a)	Distance from Boundary	% Relative winds amended for dry days only	Distance Rank	Relative winds (dry days) Rank	Multiplied Rank (b)	Risk Evaluation
Cornelius Close	135	10.0	6	4	24	Further Assessment
Ty Tanglwyst Farm	85	15.6	8	6	48	Further Assessment
Hawtorn Drive	137	12.7	6	5	30	Further Assessment
Clevis Court	27	15.4	8	6	48	Further Assessment
Queen Street	57	14.1	8	5	40	Further Assessment
Rock Cottages	24	14.0	8	5	40	Further Assessment
Cornelly Industrial Estate	155	12.0	6	5	30	Further Assessment
South Cornelly Nursing Home	161	10.6	6	4	24	Further Assessment
Maesgwyn	382	2.1	3	1	3	Insignificant

Table Note: (a) All remaining receptors have been identified as having an insignificant risk as they have been screened out within Tier 1.
(b) Farms as described in section 11.6.1 have a low sensitivity and therefore the multiplied risk rank is x 0.5

Those receptors located within South Cornelly and Ty Tanglwyst Farm have been assessed as requiring further assessment. The sources of dust associated with the continuation of quarrying at Gaens is not considered to increase, and could potentially reduce as operations occur deeper within the quarry void.

The distance to dust generating operations are greater than that assessed, as distances are to the site boundary, rather than the ROMP boundary or dust generating activities. The assessment does not take into account that there is a large swath of trees and ridge between the properties and the review site. The mature woodland and ridge provides a physical barrier to dust and reduces the wind speed, thereby encouraging deposition. Therefore existing impacts without mitigation measures are considered to be lower than assessed.

The baseline assessment shows dust levels within South Cornelly are below limits for the majority of the time but elevated on some occasions, identified through complaints and monitoring data. Therefore the mitigation measures onsite have been reviewed.

10.9.3 Risk of Impacts: Ecological Receptors

The majority of the research undertaken has focussed on the chemical effects of alkaline dusts. A summary of a review of available research on behalf of the DETR[19] concluded that:

> *'the issue of dust on ecological receptors is largely confined to the associated chemical effect of dust, and particularly the effect of acidic or alkaline dust influencing vegetation through soils.'*

Significant quantities of highly alkaline or acidic dusts with a significant risk of becoming airborne could cause some risk of impact on nearby vegetation. The review site handles limestone with is alkaline and characteristic of the immediately surrounding rock type and soils.

The closest national and international ecological site for species (Kenfig SAC) is 1.7km from the review site. This distance is considered significant, as generally the majority of dust is deposited within 100m of source[7], and therefore it is anticipated that the risk of dust leading to significant chemical effects on the plants within the SAC/SSSI is considered to be insignificant. The site has a long history of quarrying, therefore nearby locally designated SINCS have potentially been exposed to dust emissions for a significant period of time. The quantity of dust is not anticipated to increase as a consequence of ongoing operations, and therefore the risk of dust impacts at ecological receptors is considered to be insignificant.

With regard to current levels of dust deposition on the surrounding habitats, the site has historically been quarried for limestone for many decades. An Interim Advice Note (IAN) prepared as a supplement for Volume 11, Section 3, part 1 of the Design Manual for Roads and Bridges (and now incorporated into HA207/07[20]) suggests that only dust deposition levels above 1,000 mg/m^2/day are likely to affect sensitive ecological receptors. This level of dust deposition is approximately five times greater than the level at which most dust deposition may start to cause a perceptible nuisance to humans. It states that most species appear to be unaffected until dust deposition rates are at levels considerably higher than this[21].

Baseline deposition recorded within South Cornelly show 200mg/m^2/day was only exceeded once during the period of the monitoring. Due to the proximity of human receptors close to the site, by ensuring dust levels are kept to levels whereby perceptible nuisance to humans is not apparent,

[19] Department of the Environment, Transport and the Regions (DETR) 1995: *The Environmental Effects of Dust from Surface Mineral Workings – Volume Two.*

[20] Design Manual for Roads and Bridges. Volume 11, Section 3. Part 1 HA207/07. Annex F.

[21] Guidance for Undertaking Environmental Assessment of Air Quality for Sensitive Ecosystems in Internationally Designated Nature Conservation Sites and SSSI's (Supplement to DMRB 11.3.1), Interim Advice Note 61/04, March 2005

deposition is significantly below the suggested level at which ecological receptors would be affected so there is considered to be an insignificant impact on nearby ecological receptors.

10.10 Mitigation Measures

A review of onsite mitigation measures has been undertaken with respect to current permitting requirements within Permit number 19/03. Mitigation measures are defined on the basis of industry good practice guidance in accordance with MIRO, MTAN 1 and Process Guidance Note 3/08(12)[22]. A review of onsite mitigation measures has been undertaken with respect to current onsite practice. The historical planning permissions for quarrying at Gaens, which form the subject of the ROMP Review, do not include detailed conditions relating to dust controls. The purpose of the ROMP Review is to update the planning conditions to reflect modern controls, and this study aims to assist that process by identifying dust generating activities and the current approach to planning conditions.

Additional mitigation measures employed onsite in accordance with the sites permit are detailed further below and summarised within Table 11-16 and are considered to be effective. The dust source closest to South Cornelly (where complaints have been received) is the access road and internal haul road, which are considered to be the greatest source of dust. Rigorous implementation of mitigation measures for the haul roads as discussed below, is considered to be highly effective at reducing emissions.

10.10.1 Excavation and Blasting

As the base of the quarry is lowered excavation and blasting will occur deeper within the void which will help reduce dust emission. Mitigation measures for excavation and handling activities include the use of additional water suppressants in the event of dry and windy weather.

This is controlled within the permit by:

- The hole percussion drill shall be attached to a suitable dust arrestment plant;
- In dry weather conditions prior to blasting the area surrounding the charge shall be cleared of dust in a manner approved of by the regulator and shall be removed in an enclosed container. Disposal of the dust shall be carried out by means which do not give rise to dust emissions

This ensures that drilling is undertaken by an air flushed drilling rig which is fitted with a fabric filter bag which removes dust from the air venting from the drilling rig. This in combination with avoiding blasting under unfavourable conditions is considered to be highly[13] effective.

10.10.2 Transfer and Storage of Limestone

Windblown dust is minimised during material handling, as required within the permit by:

- the drop height of stone shall be minimised and whenever possible loading shall take place at sheltered points around the stockpile;
- stockpiles shall be suitably profiled and situated in sheltered parts of the quarry; and
- any accidental spillage of materials shall be cleared up as soon as possible and reused within the activity.

[22] Defra. Process Guidance Note 3/08(12) Statutory guidance for quarry processes. September 2012.

These measures, along with avoiding double handling of material where possible is considered to minimise dust emissions. Drop heights are minimised by matching shovel and dump truck such that the excavator is not physically too big to work with the chosen dump trucks. The correct matching of machines also helps to prevent overloading of dump trucks and hence prevents spillage on haul routes, which is an important source of loose material for potential dust emissions. This combined with using water sprays when required is considered to be moderately[13] effective at reducing dust emissions.

10.10.3 Processing of Limestone

Processing of limestone on site is controlled by a permit for the mobile processing plant. This is currently shielded to the south and as quarrying continues this will be undertaken within the void, therefore benefiting from reduced wind speeds. The following control measures are required within the permit:[2]

- all exposed conveyors currently fitted with an effective means of cleaning shall be sufficiently maintained to ensure that a problem of secondary dust emissions does not occur;
- mobile crushers and screens (where not totally contained) shall be fitted with water suppression over the feeding area into the crusher or screen in order to minimise dust emissions coming back out of the crusher or screen;
- discharge from mobile crushers and screens onto conveyors or other equipment shall be enclosed as far as is practicable; and
- the last metre of any final size discharge conveyor or stock pile discharge conveyor and the first 0.5 metre of the free fall of materials from the conveyor shall be fitted with a full hood and with water suppression unless the material has already been screened to remove under 3mm size.

These measures reduce the disaggregation of particles through reducing drop heights and protecting conveyors and discharge points with boarding. Water suppression ensures the surface moisture content is kept high enough to cause the fines to adhere to larger particles and reduce emissions. This is considered to be moderately effective at reducing emissions.

10.10.4 Haulage Routes

Access Road

The permit requires the hard surfaced access road shall be:

- regularly and frequently cleared of dust using a suitable mobile vacuum cleaning system at least once a day or more often when necessary;
- during dry conditions the haul road and ground surfaces subject to vehicular movement shall be kept wet and during wet conditions kept clear to minimise the carrying of mud and materials onto adjacent roads;
- all vehicles leaving the quarry void shall use the wheel wash facilities which incorporates underbody, wheel and side body sprays; and
- vehicles are sheeted as soon as possible after loading if carrying material which is <75mm.

Sheeting of vehicles reduces spillage of material and therefore re-suspension of dust from spillage on the road. Sweeping of roads and use of water for suppression, and wheel wash prevents re-suspension from passing vehicles and dust and mud being tracked out. Such traffic controls generate a moderate reduction in dust emissions[23] compared to no action being taken.

Internal Haul Road

Haulage on temporary, compacted haul roads has been identified as one of the activities with the highest potential for dust emissions in the absence of mitigation. The techniques that are employed to control dust emissions from unpaved haulage roads fall into two groups; vehicle restrictions and surface treatments.

The permit requires haul roads to be kept in good repair and be adequately drained to avoid ponding of water. The maintenance of haul roads by grading also minimises dust emissions due to less erosion of the haul road by passing vehicles.

Additionally the permit requires *'during dry conditions the haul road and ground surfaces subject to vehicular movement shall be kept wet and during wet conditions kept clear to minimise the carrying of mud and materials onto adjacent roads'.*

Watering effectively increases the moisture content of the road surface, thus conglomerating particles and reducing their likelihood to become suspended during the passage of vehicles. The effectiveness of watering has been documented to have the capability of reducing dust emissions by over 90%[24], depending on factors such as the amount of water added during each application, the period of time between applications and the metrological conditions that affect evaporation.

Vehicle restrictions are in place onsite such as speed restrictions to transport materials around the site. Such traffic controls generate a moderate reduction in dust emissions[25] compared to no action being taken.

10.10.5 Restoration

Weather conditions should be used as a factor in the timing of restoration operations, ensuring activities with a high potential for dust emissions such as handling soils are not undertaken during high wind speeds. In accordance with conventional practices of soil and overburden handling, the soils would not be moved in extreme wet or dry conditions, in order to avoid damage to the soil structure by smearing or compaction. Double handling of material and drop heights are minimised where possible.

10.10.6 Management

The permit requires the monitoring and recording keeping to be undertaken.

The success of dust control measures is dependent on the awareness of site personnel and their willingness to promptly apply these actions when necessary. There is a trained and responsible site supervisor / manager on site during working hours to ensure dust emissions are under control. Responsibilities are allocated to specific personnel to ensure dust generation are effectively controlled.

[23] EPA, 2006. Unpaved Roads. http://www.epa.gov.uk/ttn/chief/ap42/ch13/final/c13s0202.pdf. Available on Web on April 2008.

[24] Environment Effects of Surface Mineral Workings. DoE, October 1995

[25] US EPA, 2006. Unpaved Roads. http://www.epa.gov.uk/ttn/chief/ap42/ch13/final/c13s0202.pdf. Available on Web on April 2008.

All personnel on site should understand their responsibility to ensure the generation of particles is minimised. Each employee is made aware of the importance of dust control and the most effective measures available to minimise such emissions.

Regular auditing of onsite operations covering all aspects of pollution control, environmental management and general housekeeping should be undertaken.

10.10.7 Mitigation Measures Summary

These mitigation measures are considered to be effective at reducing dust emissions. A summary of the mitigation measures that are employed at the site are presented in Table 10-16.

Table 10-16: Summary of Dust Control Measures and Estimate of Effectiveness

Site Operation	Dust Control Measures	Estimate of Effectiveness
Mineral Extraction/ Handling:	Use of water sprays as and when necessary	High
	Vehicles not overloaded and reduction of drop heights	Moderate
	Use of dust suppression on drill rigs and removal of fine material prior to blasting	High
	Avoid double handling of material	Moderate/Low
Processing	Dust suppression sprays	High
	Discharge enclosed as far as possible	High
	Enclose and cleaning of conveyors	High
	Ensure base of stockpiles clearly marked and profiled and shielded from wind where possible, and kept moist in dry weather	Moderate
Unpaved Haul Roads	Controlled use of fixed haul routes	Moderate/High
	Haul routes to be regularly maintained by grading to minimise dust generation	High
	Speed controls to be implemented and enforced on all haul routes	Moderate
	Water bowsers to be used as required	High
Paved Roads	Controlled use of fixed haul routes	Moderate/High
	Speed controls to be implemented and enforced on all haul routes	Moderate
	Wheel wash installed and used	Moderate
	Regular sweeping of metalled access road using road sweeper	Moderate
	Water bowsers to be used as required	High
	Water sprays to be used as required	High
	Minimise the duration of activity	High/Moderate
Restoration:	Avoid soils handling during adverse weather conditions	High
	Optimise timing regarding weather	High
	Temporary cessation of activities in the event of unacceptable dust emissions in the vicinity of receptor properties.	High

10.11 Residual Effects

Mitigation measures described in the above section are employed on site. It is considered that with these mitigation measures effectively employed, the dust impact at surrounding receptors would be acceptable or insignificant. A summary of the predicted residual impact assuming the effective implementation of mitigation measures at each receptor location is presented in Table 11-17.

Table 10-17: Residual Impacts Following Mitigation

	Receptor Name	Further Assessment Required	Residual Impact
1	Mount Pleasant Farm	No	Insignificant
2	Seaview	No	Insignificant
3	Cornelius Close	Yes	Acceptable
4	Ballas Cottage	No	Insignificant
5	Ty Tanglwyst Farm	Yes	Acceptable
6	Hawtorn Drive	Yes	Acceptable
7	Clevis Court	Yes	Acceptable
8	Queen Street	Yes	Acceptable
9	Rock Cottages	Yes	Acceptable
10	Grove Farm	No	Insignificant
11	Cornelly Industrial Estate	Yes	Acceptable
12	Dan-y-graig Farm	No	Insignificant
13	South Cornelly Nursing Home	Yes	Acceptable
14	Maesgwyn	Yes	Acceptable

In summary the continued dust impact at the receptor locations surrounding the quarry are considered to be at insignificant or acceptable level with effective implementation of mitigation measures and are considered to be reversible once extraction is complete.

10.12 Cumulative Effects

There is the potential for cumulative impacts as a result of quarrying operations in the area, which, in addition to Gaens Quarry, includes the operational Cornelly Quarry, and the currently mothballed Grove Quarry, which together, form the Cornelly Group of Quarries. There is also a concrete plant (Braceys) within the industrial area in South Cornelly.

The potential for additional cumulative impacts above the baseline of the operational Cornelly, Gaens Quarries and Concrete batching plant is associated with the potential re-commencement of quarrying at Grove Quarry.

Dust impact assessments have been undertaken as part of EIA's accompanying the Cornelly Quarry ROMP Review, the Grove ROMP Review, the Gaens Quarry Romp Review, and the Cornelly / Grove Quarry IDO Periodic Review. The majority of receptors have been assessed at an insignificant risk of impacts from the separate quarrying operations.

A cumulative deposited dust impact assessment has been undertaken considering the frequency of exposure from all quarries within 500m of the receptor. The assessment methodology does not take into account the baseline situation and assumes no existing site operations and mitigation measures. In addition, the distance used for the assessment is that to the closest point quarry boundary and therefore the dust generating activities within the different quarries will be at a greater distance to the distances assessed. Therefore the assessment considers a worse case scenario. Full results from the cumulative assessment are in Appendix 10/3, and residual impacts with mitigation measures employed are displayed in Table 11-18 below.

Table 10-18: Residual Cumulative Impact Assessment

Receptor	Cornelly Quarry	Grove Quarry	IDO area	Gaens Quarry	Cumulative
Mount Pleasant Farm	Insignificant	Insignificant	Acceptable	Insignificant	Acceptable
Seaview	Insignificant	Acceptable	Acceptable	Insignificant	Acceptable

Ballas Farm	Insignificant	Insignificant	Insignificant	Insignificant (a)	Insignificant
Ballas Cottage	Acceptable	Insignificant	Insignificant	Insignificant	Acceptable
Ty Tanglwyst Farm	Insignificant	Insignificant	Insignificant	Acceptable	Acceptable
Former Stormy Down Airfield	Acceptable	Insignificant	Insignificant	Insignificant (a)	Acceptable
Rock Cottages (b)	Acceptable	Insignificant	Insignificant	Acceptable	Acceptable
Grove Farm	Insignificant	Acceptable	Insignificant	Insignificant	Acceptable
Cornelly Industrial Estate (b)	Acceptable	Insignificant	Insignificant	Acceptable	Acceptable
Dan-y-graig Farm	Insignificant	Acceptable	Insignificant	Insignificant	Acceptable
Breaker Yard	Acceptable	Insignificant	Insignificant	Insignificant (a)	Acceptable
South Cornelly Nursing Home(b)	Acceptable	Insignificant	Insignificant	Acceptable	Acceptable

(a) Greater than 500m from site and therefore insignificant impact

(b) Additional receptors within South Cornelly were assessed within the Gaens ROMP review, however the 3 discussed are considered representative of these properties within South Cornelly.

Table 11-18 shows the residual risk of cumulative impact at all receptors is insignificant or acceptable. This is a worse case assessment as for many of the receptors the impact will remain unchanged, as the operations within Cornelly and Gaens Quarry are considered to remain unchanged.

The baseline data shows that PM_{10} is well below the limit of 40µg/m^3,at 23.5µg/m^3 for the existing operations at Cornelly and Gaens Quarry (measured at the monitoring station at the entrance to Gaens Quarry). As existing concentrations are 'well below' the limit, there is a large 'headspace' of 16.5µg/m^3 before the limit of 40µg/m^3 would be reached. Therefore the risk that operations within Grove Quarry will cause an exceedance of the AQS objective is low.

10.13 Recommendations

The advice set out in, MPPW and MTAN1 is that planning conditions should not duplicate controls which are available and in place via other regulatory regimes. In the case of Gaens Quarry, a separate Permit is in place which controls dust emissions associated with the crushing and screening plant, extraction, stockpiles, material handling and haul roads.

It is recognised that Gaens Quarry has a dust control regime, supplemented by good practice dust control management measures, and therefore with rigorous implementation of these measures (particularly with regard to haul roads) no additional dust control mitigation measures over and above those which are already in place are recommended.

10.14 Planning Conditions

It follows that detailed dust control conditions are not deemed to be necessary given the separate existing controls which are in place via the Permit. However, opportunities are available to include a general dust control protocol (a Dust Action Management Plan or similar) as a condition which draws upon the key elements of dust mitigation, but in a way which does not duplicate the PPC Permit controls and requirements.

This is reflected in the schedule of updated planning conditions which accompanies the Review application.

10.15 Summary

This assessment has considered the potential impacts of continuing operations within the Gaens ROMP review area and remaining Gaens Quarry site. The assessment has considered the relevant legislation, baseline conditions, activities associated with the site including haulage, excavation activities, storage and processing of material and restoration of the site.

Impacts on local air quality from traffic emissions were been screened out of further assessment as traffic generated by the proposed development would be below the DMRB criteria and therefore considered to be neutral. Additional assessment quantified impacts as a result of existing HGV movements which were assessed as negligible.

The potential impacts of the development have been assessed in terms of potential emissions of particulates (dust). Two assessments have been undertaken; the first to assess the PM_{10} fraction for which Air Quality Standards exist, and the second to assess the coarse fraction dust which is typically associated with amenity issues.

An assessment of PM_{10} was completed following guidance within LAQM.TG(09) considering background PM_{10} level and distance to receptors. Background levels are 'well below' the limit. Continuation of quarrying operations at Gaens Quarry are not considered to lead to a significant increase in PM_{10} emissions.

A semi-quantitative assessment of deposited dust undertaken identified the potential sources of dust onsite, which were considered to be unchanged as part of the ongoing development. Receptors were ranked in terms of the risk of dust impact which is dependent on the distance from the site boundary, the frequency of wind direction and rainfall patterns.

Using this method receptors within South Cornelly and Ty Tanglwyst Farm were assessed as 'requiring further assessment' however continued impacts were considered to be less than assessed due to the assumptions in the methodology which, inter alia, rely upon distances between the receptors and the site boundary, rather than distances to the dust generating activities. The continued operation of the quarry is not considered to increase impacts. Baseline data shows there have been some complaints and elevated dust results at times. Current mitigation measures implemented onsite in accordance with best practice and the requirements of the permit are considered to be effective, with rigorous management and implementation, dust emissions from the site are assessed as acceptable or insignificant.

The potential for dust impacts on the surrounding ecological sites has been assessed as insignificant.

All potential dust impacts from the proposed development are considered to be reversible i.e. the risk of impact will cease on completion of the extraction and restoration activities at the site. The impacts from the quarry are considered to be medium term with no significant impacts on local air quality on the completion of the development.

11.0 TRANSPORTATION

11.1 Introduction

Following consideration of the potential implications of the proposed development, the Welsh Government stated within its Scoping Direction under the heading "*Transport*": "*The impacts of traffic (noise, dust, emissions and impact on local road network) arising from any increased extraction rates should be included together with proposals for traffic management and other measures to reduce impacts on the local highway, including the cleanliness of the public highway (Porthcawl Road) in South Cornelly at the junction of the site access road with the main road. The assessment should provide information on traffic flows on the A4229, and identify the component of HGV traffic associated with the ongoing operations at Grove Quarry*". ([sic] read Gaens Quarry).

In terms of highway and transport issues, the proposals considered under this application will result in no material change when compared with the existing situation, as the average annual output of approximately 150,000 tonnes per annum and the operational hours of the site will remain as existing i.e. 07:00 – 17:00 Monday to Friday and 07:30 – 12:30 on Saturday, with no working on Sundays or Bank Holidays.

11.2 Site Access

The site is served via a priority T access with Porthcawl Road approximately 150m to the south of its roundabout junction with the A4229 South Cornelly Bypass and B4283 Porthcawl Road, which continues north from the junction.

The site access extends approximately 28.3m along the east side of Porthcawl Road between the kerb tangent points which form the bellmouth. The kerb radii extend back into the site access which reduces to a nominal effective width 6.7m at the entrance gates, which are set back 13m from the road edge.

The access itself is surfaced in tarmacadam and is approximately level for a distance of around 10m before it rises from Porthcawl Road into the site. It was noted during the site visit that there are several potholes on the level section of the bellmouth which had caused water to pool.

Visibility at the access to Gaens Quarry was measured to extend 116m to the near edge, 128m to the centreline of the oncoming traffic lane and 150m to the centreline of the Porthcawl Road to the right (north) from a 2.4m set-back (X distance). The centreline distance of 150m coincides with the edge of the roundabout junction to the north, at which point the speed limit reduces to 30 mph when entering South Cornelly on the approach to the site access.

The comparable visibility to the left (south) extends beyond the required 40m identified in Table B of TAN 18 for 85th percentile wet weather speeds of 30 mph to the near edge, 50.7m to the centreline, 55.7m to the centreline of the oncoming traffic lane and 67.5m to the far edge of Porthcawl Road. At the build out, the width of the running carriageway is 5.25m. Whilst this is sufficient to allow two opposing vehicles to pass each other, it is unlikely that vehicles would be overtaking at that point and therefore approaching from the south in the near lane, particularly when taking into account the proximity of the upcoming speed hump immediately to the north of the Gaens Quarry access.

11.3 Baseline Conditions

11.3.1 Highway Infrastructure

As stated above, Gaens Quarry is accessed via Porthcawl Road approximately 150m to the south of its roundabout junction with the A4229 to the north of South Cornelly.

In the vicinity of the site access, Porthcawl Road has a nominal width of 7.3m to the north and it is subject to a speed limit of 30 mph (50 kph). Vehicle speeds along this section are controlled by a speed hump immediately to north of the quarry access and another approximately 85m beyond.

The route is lit and a pedestrian footway is provided along the west side of the carriageway with a grass verge on the east.

On the approach to the roundabout with the A4229/B4283, the width of Porthcawl Road increases top provide two traffic lanes for turning vehicles. A kerbed island is provided to segregate the traffic movements into and out of the roundabout junction, at which point the speed limit increases to the national limit of 60 mph on single carriageway and 70 mph (113 kph) on dual carriageway routes.

The roundabout is lit and has a diameter of approximately 50m. Turning right at the roundabout onto the A4229 directs traffic northeast towards M4 Motorway Junction 37, which is 0.7km distant. The A4229 link to the M4 Motorway is constructed to dual carriageway standard with the opposing 7.3m wide carriageways providing two traffic lanes in each direction. The route is a Clearway, where stopping is prohibited, although lay-bys are provided on both sides immediately to the north of the junction. The route is subject to the national speed limit of 70 mph.

The M4 Motorway Junction 37 is a grade-separated interchange that provides entry and egress to/from the M4 for westbound and eastbound traffic.

Returning to the roundabout to the north of South Cornelly where Porthcawl Road connects with the A4229, turning left at the roundabout when approaching from Gaens Quarry directs traffic in a generally southern direction along the continuation of the A4229 from M4 Junction 37. This southern section of the A4229 effectively forms a bypass around South Cornelly.

The bypass is a single carriageway route with a nominal width of 7.3m and is subject to the national speed limit of 60 mph (96 kph). It is unlit beyond the roundabout junctions and has no other accesses or junctions along its 2km length between the northern roundabout and the next junction to the south, which is known as Smokey Cottage roundabout. Thuis section of the A4229 is also a Clearway, where stopping is prohibited, as are pedestrians; although the sign confirming the latter when leaving Smokey Cottage roundabout has almost faded completely. The entry width at the roundabout is 7.4m divided into two traffic lanes.

Beyond Smokey Cottage roundabout the A4229 continues towards Porthcawl.The A4229 is classified as a Strategic Road and also a Principle Road in the local route hierarchy, and as such is effectively the preferred corridor for HGV traffic travelling to or from the area.

Returning to the Smokey Cottage roundabout, the junction is a four-arm, at-grade roundabout, which is lit and has a diameter of approximately 40m. Porthcawl Road is the northern approach, Heol-Y-Splot is the western approach and the A4229 forms the southern and western approaches.

To the southern section of the A4229 to/from Porthcawl is a single carriageway with a nominal width of 7.6m on the approach to the junction, which widens to an entry width of 8.5m divided into two traffic lanes at the roundabout itself. There are bus stops located on both sides of the route and an access to Grove Golf Club on the west side of the route. The A4229 is lit for approximately 0.5km to the south of the junction and a pedestrian footway is provided along the east side of the carriageway towards Porthcawl.

The western approach to the roundabout is the South Cornelly bypass, which has an entry width of 7.4m divided into two traffic lanes.

The northern approach, Porthcawl Road, has a nominal width of 5.5m and provides access to/from South Cornelly. The approach to Smokey Cottage roundabout has an entry width of 8m divided into two traffic lanes. Porthcawl Road also provides the egress from a fuel station which sits in the northeast corner of the roundabout in addition to South Cornelly Trading Estate and Leraj Restaurant.

Heading north along Porthcawl Road from Smokey Cottage roundabout directs traffic into and through South Cornelly approximately 770m to the roundabout to the north of Gaens Quarry. Porthcawl Road is subject to a 30 mph speed limit and incorporates traffic calming speed humps along its length between the roundabout junctions. In addition, there are also kerbed build-outs/chicanes to channelise and prioritise traffic movements along the rosad corridor.

The eastern approach to Smokey Cottage roundabout is Heol-Y-Splot, which is a 1.25km link extending east from its roundabout. Heol-Y-Splot is now a cul-de-sac following a formal road closure in 2007 which enabled quarrying operations to take place through the alignment of the former highway as part of the implementation of the existing quarrying planning permissions at Cornelly Quarry. Heol-Y-Splot thus predominantly serves as an access route to Cornelly Quarry (and Grove Quarry) and is not used as a ‘through route’ by members of the public. Grove Quarry is currently mothballed whilst extraction is concentrated at Cornelly Quarry.

The entry to the Smokey Cottage roundabout at the western end of Heol-Y-Splot is 7.9m wide and is divided into two lanes. Immediately to the east of the roundabout on the Heol-Y-Splot exit and approximately 15m from the edge of the circulatory carriageway of the junction there is the access on the left (north) to the fuel station/garage which sits between Heol-Y-Splot and Porthcawl Road.

Immediately to the east of the access to the fuel station from Heol-Y-Splot there is an access to South Cornelly Trading Estate on the left (north) side, which contains 35 commercial units. This is also an access only and again the egress from the Trading Estate connects to Porthcawl Road immediately to the north of the fuel station exit. The traffic leaving the Trading Estate must Give Way to traffic using the “*Drive Thru*” facility at the Leraj Restaurant, which shares the exit point to Porthcawl Road with the Trading Estate traffic.

The access to the restaurant is to the north of the restaurant itself from Porthcawl Road and is parallel to but south of the access to the Trading Estate.

Continuing east along Heol-Y-Splot from the Smokey Cottage roundabout, there is a second access to the Trading Estate, beyond which the carriageway narrows to 4.5m between bridge parapet walls over a former railway line, approximately 85m from Smokey Cottage roundabout. Beyond the bridge the carriageway widens again in the vicinity of the access to Grove Quarry, which lies on the right (south) side and currently accommodates a recycling operation (‘The Recycling Company’)

11.3.2 Existing Traffic Flows

In the absence of any recent traffic survey data on the local highway network, new traffic surveys were undertaken in October 2013. As part of the periodic reviews of Cornelly and Grove Quarries an observed count was undertaken at Smokey Cottage roundabout at the western end of Heol-Y-Splot on Thursday 22nd October between 07:00 – 19:00, which recorded all turning movements at the junction during that period.

In addition, as part of the review of Gaens Quarry, an Automated Traffic Counter (ATC) was installed over the same period to record traffic flows on Porthcawl Road to the north of the site access.

In terms of the Smokey Cottage roundabout, the survey results revealed that the AM peak hour occurred between 08:00 – 09:00 and also 08:15 – 09:15 when the same volume of traffic passed through the junction. However, a review of the data during the two hours where the same number of movements were recorded revealed that the later hour had a higher content of large vehicles. As a result, when assessed on the basis of total loading on the junction, the AM peak was established to occur between 08:15 and 09:15 when a total of 1707 vehicles including 125 large vehicles passed through the roundabout. The PM peak hour occurred between 16:45 and 17:45 when a total of 1655 vehicles including 39 large vehicles.

The turning counts at Smokey Cottage roundabout during the peak hour periods are tabulated below.

Table 11-1 Smokey Cottage Roundabout – AM Peak Hour Observed Traffic Flows

To / From	A	B	C	D	Total
A	0 (0)	24 (6)	62 (9)	21 (5)	107 (20)
B	1 (1)	2 (2)	3 (1)	19 (16)	25 (20)
C	51 (9)	70 (1)	0 (0)	777 (20)	898 (30)
D	11 (7)	63 (22)	603 (26)	0 (0)	677 (55)
Total	63 (17)	159 (31)	668 (36)	817 (41)	1707 (125)

A = Porthcawl Rd (N) B = Heol-Y-Splot C = A4229 (S) D = A4229 (N)

XX = Total Vehicles (YY) = Heavy Vehicles in Total

Table 11-2 Smokey Cottage Roundabout – PM Peak Hour Observed Traffic Flows

To / From	A	B	C	D	Total
A	0 (0)	16 (2)	107 (5)	16 (0)	139 (7)
B	2 (0)	0 (0)	10 (0)	33 (6)	45 (6)

C	33 (4)	33 (0)	0 (0)	515 (6)	581 (10)
D	2 (0)	44 (8)	844 (8)	0 (0)	890 (16)
Total	37 (4)	93 (10)	961 (13)	564 (12)	1655 (39)

A = Porthcawl Rd (N) B = Heol-Y-Splot C = A4229 (S) D = A4229 (N)

XX = Total Vehicles (YY) = Heavy Vehicles in Total

The ATC on Porthcawl Road was fixed to the direction sign to the south of the roundabout. The average daily traffic flow over the seven day survey period was found to be 2756 vehicles, of which 115 (4.17%) were large vehicles (HGVs or Buses/PSVs). Of these, 108 were HGVs, which represents 3.92% of the total traffic volume. Between Monday and Friday, the average daily flow over 24 hours was found to be 2928 vehicles including 143 large vehicles, which equates to 4.88% of the overall daily volume. Of these, 134 were HGVs.

In terms of daily flows, between Monday and Sunday the total traffic volume varied between 2063 (Sunday) and 3202 (Friday), resulting a range of 1139 movements from day to day. If the weekend flows are excluded, the range of daily variation reduces to 448 movements between the Friday peak and 2754 movements on Monday.

The daily large vehicle flows varied between 4 on Sunday and 164 on Friday, giving a range of 160 from day to day during the week. If the weekend flows are excluded, the range reduces to 38 movements between the Friday peak and 126 movements on Monday.

The HGV flows were found to vary between 4 on Sunday and 153 on Friday, resulting in a range of 149 movements; which reduced to 34 movements when excluding the weekend period between the Friday peak and 119 movements on Monday.

The average AM peak flow on Porthcawl Road was found to fall between 08:00 – 09:00 when 270 movements were established. The PM peak hour occurred between 16:00 – 17:00 when 258 movements were recorded as the weekday (Monday to Friday) average. The hourly flows during the AM peak hour varied between 247 (Tuesday) and 306 movements (Thursday), giving a range of 59 movements from day to day during the AM peak hour.

The comparable flows during the PM peak hour varied from 218 on Monday to 293 on Friday, giving a range of 75 movements from day to day during the PM peak hour.

The busiest hour of the week on Porthcawl Road recorded at the ATC site was 306 movements (196 northbound / 110 southbound) between 08:00 – 09:00 on Thursday.

The average traffic speeds during the survey were found to be 27.7 mph northbound and 26.5 mph southbound, increasing to 33.1 mph northbound and 31.5 mph southbound at the 85th percentile level.

During the period of the ATC surveys, vehicle flows at the Gaens Quarry weighbridge were recorded. The HGV total number of HGV (in + out) movements attributable to the site are tabulated below.

Table 11-3 HGV Total Number (in + out)

Thurs	Fri	Sat	Sun	Mon	Tue	Wed
50	66	4	0	36	54	40

It is understood that approximately 99% of the Gaens Quarry traffic travels to/from the north of the access to the A4229 and then to/from M4 Junction 37. Only occasional deliveries take place within South Cornelly or Porthcawl.

Assuming that all of the Gaens HGV traffic travelled to/from M4 Junction 37 during the survey period, by comparing the HGV movements recorded at the weighbridge with those at the ATC site, it is apparent that the Gaens Quarry traffic represents between 30.3% and 43.1% of the HGV traffic recorded on Porthcawl Road between Monday and Friday, and 4.7% on Saturday.

In terms of large vehicles, including buses/PSVs, the proportion of Gaens Quarry traffic reduces to between 28.6% and 40.2% Monday to Friday and 4.5% on Saturday.

During the period of the traffic surveys, to Cornelly Quarry were recorded. The numbers of loads delivered to and from the site were recorded daily. The combined total number of HGV movements (in + out) associated with Cornelly Quarry were:

Table 11-4 Loads Delivered to and From Site

Thurs	Fri	Sat	Sun	Mon	Tue	Wed
348	312	58	0	354	354	526

The range of daily traffic flows at Cornelly Quarry is consistent with the average figure of around 500 HGV movements per day previously identified based on the annual production at the site.

As there are accesses to the fuel station and South Cornelly Trading Estate immediately beyond the roundabout on Heol-Y-Splot, the flows along the remainder of the route beyond the bridge would be lower as some traffic recorded at the roundabout exit would turn left into the Esso fuel station or South Cornelly Trading Estate.

During the 12 hour survey a total of 425 HGV movements were recorded between 07:00 – 19:00. A total of 242 HGVs left the roundabout travelling eastbound and 183 entered the roundabout travelling westbound, which compared well with the weighbridge data from Cornelly Quarry of 177 movements, when taking into account the other potential sources of HGV traffic along Heol-Y-Splot, such as the recycling operations run by separate companies, which could readily account for an additional 6 HGVs per day.

Assuming the same 6 additional HGVs also accessed the businesses to the east of the bridge on Heol-Y-Splot, it is apparent that 59 HGVs (242 – 183) accessed either the Esso fuel station or South Cornelly Trading Estate having left the roundabout junction.

11.3.3 Existing Highway Safety

In order to assess the safety performance of the local highway network, collision data was obtained from the Highway Authority covering the most recent 5 year period available (01 July 2008 to 30 June 2013).

The area of search included the remaining length of Heol-Y-Splot, Smokey Cottage roundabout, the A4229 between Smokey Cottage roundabout and M4 Junction 37, plus the length of Porthcawl Road through South Cornelly between Smokey Cottage roundabout and the roundabout junction with the A4229 to the north.

Within the study area a total of 11 accidents have been recorded over the 5 year period. However, it was found that none of the incidents involved HGVs and none of them occurred along Heol-Y-Splot.

There were two recorded accidents at the Smokey Cottage roundabout; two along the A4229 South Cornelly bypass; three at the roundabout to the north of South Cornelly; one on the dual carriageway between that roundabout and M4 Junction 37; and three distributed along the length of Porthcawl Road through South Cornelly.

In the event there is a particular feature of the highway network that results in compromised safety, it is common to find a number of collisions in the same location that share similar characteristics. In this case, where more than one collision has occurred (i.e. at the two roundabouts), the details of the recorded collisions were analysed. It was found that each incident was distinctly different from the other in terms of the manoeuvres being undertaken and the causes of the incidents. It is therefore concluded that there are no features of the existing highway network that inherently compromise safety to an unacceptable level.

In the absence of any recorded collisions involving HGVs on the local roads within the last five years, on a network that routinely accommodates HGV traffic, applying the evidence-based approach advocated in current highway design guidance indicates the existing road network can safely accommodate the HGV traffic associated with the existing activities at Gaens Quarry and other businesses which attract such vehicles.

11.4 Development Proposals

11.4.1 Application Details

In the context of transport and highways issues, the key features of the development are summarised as follows:

- The extraction and distribution of materials from Gaens Quarry is proposed to continue for the next 15 years covered by this ROMP process.
- The predicted output/throughput at the site are anticipated to remain at current/recent levels of 150,000 tonnes per annum on average.
- The activities at Gaens Quarry are predicted to continue to attract in the order of 31 loads / 62 HGV movements per average day on the local highway network, which is consistent with existing activities on site.
- The existing site access, which has an excellent safety record, will be used to serve the site for the remainder of its active life, in accordance with the existing planning permission.
- The types of HGVs serving the site will be consistent with current and historic operations, which have been safely accommodated on the local highway network.
- The majority of HGVs except for the occasional vehicle making a local delivery to satisfy demand in the immediate vicinity of the site would travel along the A4229 to/from Junction 37 of the M4 Motorway, in accordance with existing movements to/from the site.
- The operating hours will remain in accordance with the existing planning permission and current/recent activities.
- In effect, the proposed development will result in no change to the network when compared with the existing planning permission which is subject to the review process.

11.4.2 Trip Generation

Based on the existing and recent activities at the site, the extraction and distribution of 150,000 tonnes of material per annum will result in an average of 62 HGV movements per day (31 in/31 out) based on 275 working days per annum and an average payload of 18 tonnes per vehicle. This is generally consistent with the range observed during the period of the surveys undertaken as part of this review.

All traffic travels along Porthcawl Road, with almost all vehicles heading to/from the north of the site access, thereby restricting the use of local roads to a length of 150m between the site and the A4229 principal road network beyond.

The majority of movements to/from the site then travel along the A4229 to the north to/from Junction 37 of the M4 Motorway.

11.4.3 Highway Infrastructure

Porthcawl Road is the main vehicular access to South Cornelly and is routinely used by HGV traffic which is unrelated to activities at Gaens Quarry. Its width to the north of the site access, at 7.3m, is consistent with the standard of design for industrial estate roads and distributor roads, and is the same width as the South Cornelly bypass.

To the south of the site access the width of Porthcawl Road has been deliberately restricted by constructing kerbed build-outs to form chicanes and slow traffic as part of a wider traffic calming regime including the installation of speed humps. This infrastructure serves to slow traffic speeds through South Cornelly and discourage through traffic by encouraging drivers to use the faster route around the A4229 South Cornelly bypass.

Therefore, whilst all vehicle types may travel along Porthcawl Road through South Cornelly, the majority of drivers choosing to do so would have a locally based need to do so, such as an origin or destination within the village.

The A4229 is a Principal Route and as such is a route along which HGV traffic is encouraged to travel in order to avoid roads with a lower status in the network hierarchy, which may be considered less suited to such traffic.

The A4229 is a high standard route constructed to modern design standards and bypasses South Cornelly and the potentially sensitive receptors to traffic related impacts.

Such direct linkage to the strategic highway network from the site access is considered to be beneficial in terms of minimising the potentially adverse effects of necessary traffic activity.

11.5 Development Impacts

11.5.1 Environmental Impacts

In terms of the environmental effects of the proposed development related to transport matters, the potentially sensitive receptors are limited to the properties adjacent to the access road and those along the 150m length of Porthcawl Road on its west side between the site access and A4229, or thereabouts.

The A4229 bypasses South Cornelly and provides a high standard strategic link to the M4 Motorway and also benefits from having few sensitive receptors within its immediate vicinity, thereby minimising the impact associated with traffic activity.

In terms of the limited number of HGVs making local deliveries, if the materials being delivered from the site were sourced from elsewhere, the same types of vehicle would still travel along the local routes, albeit from further afield, which would exacerbate the potential adverse impacts over a wider area of the network.

It is also noteworthy that the HGVs attracted to the site are already anticipated to travel along the road network under the extant planning permission.

The site incorporates surfaced haul roads along which HGVs must travel before joining the public highway to minimise the potential for detritus to be transferred to the external routes in the area.

11.5.2 Highway Capacity Impacts

In terms of highway capacity impacts, the existing quarry has operated for many years at or around the current levels of output, which have been and continue to be accommodated on the local highway network.

The maximum flow recorded on Porthcawl Road in any hour was 303 movements. This may be compared with the hourly capacity of single track roads with passing places of up to 300 vehicles per hour established during a study undertaken by the Transport and Road Research Laboratory (TRRL), which is now known as TRL.

The findings of the study were summarised: *"Results from the TRRL studies indicate that simply in terms of their capacity for carrying moving traffic single-lane carriageways, correctly designed, are unlikely to incur significant increases in delay compared with traffic in free-flow conditions, at flow levels of up to 300 vph (total two-way)",* where vph is vehicles per hour.

Whilst there is a section of Porthcawl Road to the south of the site access that effectively operates as single-lane carriageway it is a short length and has been deliberately created by constructing kerbed build-outs, on either side of which vehicles may pass each other freely. As a result, the capacity of Porthcawl Road is at least 300 vehicles per hour. It is also noted that HGVs associated with Gaens Quarry do not routinely travel along the narrowed section to the south of the site access.

The section of Porthcawl Road to the north of the site access has a nominal width of 7.3m. Table 2 of TA 79/99 "*Traffic Capacity of Urban Roads*" advises carriageways of this type have a design capacity of between 1900 and 2650 vehicles per hour. The lower figure represents busy high streets with frequent accesses, unrestricted loading, parking etc. which restrict through movement by creating single lane sections, whilst the higher flow represents a high standard route carrying predominantly through traffic with limited access, such as the A4229 South Cornelly bypass.

Taking the lower capacity of 1900 movements for the traffic calmed section of Porthcawl Road, based on the maximum hourly flow of 303 movements it is apparent that the link would retain a reserve capacity of 1597 movements, which equates to some 84%.

The single carriageway section of the A4229 South Cornelly bypass has a nominal width of 7.3m. Table 2 of TA 79/99 "*Traffic Capacity of Urban Roads*" advises carriageways of this type, which have fewer accesses and different characteristics to the section of Porthcawl Road with the same width, have a design capacity of 2650 vehicles per hour. This design capacity may be compared with the peak hourly flow of 1513 recorded on the A4229 to the northwest of Smokey Cottage roundabout and 1579 on the A4229 to the south of the junction.

Taking the higher of the two flows as the baseline, it is apparent that the A4229 retains a reserve capacity of 1071 movements during the peak hour of demand, which equates to almost 41% of the available capacity of the route.

The capacity of the Smokey Cottage roundabout was also assessed. The observed traffic flow data recorded during the CTC was input to ARCADY, the standard computer model for roundabout junctions, together with the relevant geometric parameters, which were derived from on-site measurements and Ordnance Survey digital mapping data.

The results of the ARCADY assessments for the existing situation are set out below:

Table 11-5 ARCADY Assessments

Approach	Maximum Ratio of Flow to Capacity		Maximum Queue (Vehs)		Inclusive Delay (Mins/Veh)	
	AM	PM	AM	PM	AM	PM
A	0.127	0.161	0.1	0.2	0.07	0.07
B	0.044	0.058	0.0	0.1	0.09	0.07
C	0.537	0.341	1.2	0.5	0.06	0.05
D	0.500	0.602	1.0	1.5	0.07	0.08

A = Porthcawl Rd (N) B = Heol-Y-Splot C = A4229 (S) D = A4229 (N)

The results of the ARCADY assessment confirm that under the peak traffic conditions considered, the Smokey Cottage roundabout operates efficiently. The maximum Ratio of Flow to Capacity (RFC) of 0.602 compares favourably with the desirable maximum of 0.85, which itself retains a 15% reserve capacity below the RFC of 1.0 at which the theoretical capacity is reached.

It is also apparent that there are no significant queues or delays forming on any of the approaches to the roundabout during the peak hour periods considered.

11.5.3 Highway Safety Impacts

As is apparent from the review of recorded collisions over the most recent 5 year period available, the existing road network is capable of accommodating HGV activity associated with both the site and other businesses in the area which routinely attract such vehicles,

The last 5 years includes a period when operations at the site were ongoing at the levels predicted to continue into the future, resulting in similar traffic volumes on a day to day and annual basis.

In the absence of any recorded collisions involving HGVs on the local road network within the last five years on a routes that routinely accommodate HGV traffic, applying the evidence-based approach advocated in current highway design guidance indicates there is no reason to believe that the HGV activity associated with the ongoing activities at the site, which fall within previously approved levels and timescales, would have an unacceptable impact or represent an increased level of risk to safety.

11.6 Mitigation Measures

The existing road network currently accommodates the traffic associated with the activities at Gaens Quarry, which are predicted to continue as existing for the period covered by the ROMP process.

As has been established, the existing road network retains sufficient capacity to accommodate the traffic and has a sufficient level of geometric design to facilitate safe access, as demonstrated by the lack of accidents involving HGVs within the study area in recent years.

In general terms, the highway network is therefore considered to be acceptable and no geometric improvements are required to accommodate the ongoing activities at Gaens Quarry beyond routine maintenance of verge areas to ensure that the visibility provision is maximised and also that the surface of the access is maintained to prevent potholing and pooling of water in order to maintain highway cleanliness.

11.7 Residual Impacts

Following implementation of the minor maintenance works, there should be no residual impacts in terms of transport matters.

11.8 Cumulative Effects

At present, Grove Quarry, which lies adjacent to and west of Cornelly Quarry, has been mothballed. Whilst there is a degree of uncertainty regarding the resumption of extraction at Grove Quarry, it could resume within the period of this ROMP Review (or beyond the current ROMP Review period).

Lafarge Tarmac, which controls Grove Quarry, has identified a notional output of 250,000 tonnes per annum over a 5.5 day working week, which equates to 270 working days per annum. The proposed hours of working would be 07:00 – 19:00 Monday to Friday and 07:00 – 13:00 on Saturdays.

Based on an average payload of 18 tonnes, Grove Quarry could attract an average of 51 loads / 102 HGV movements per day and 5 loads / 10 movements per hour.

In order to confirm that the additional traffic would not have an unacceptable impact on Smokey Cottage roundabout, an additional 5 HGVs were added to the inbound and outbound movements between the A4229 South Cornelly bypass and Heol-Y-Splot during both the AM and PM peak hours. The capacity of the roundabout was then reassessed using ARCADY and the following results were obtained:

Table 11-6 Capacity of the Roundabout

Approach	Maximum Ratio of Flow to Capacity		Maximum Queue (Vehs)		Inclusive Delay (Mins/Veh)	
	AM	PM	AM	PM	AM	PM
A	0.128	0.163	0.1	0.2	0.07	0.07
B	0.053	0.070	0.1	0.1	0.10	0.07
C	0.540	0.342	1.2	0.5	0.06	0.05
D	0.507	0.609	1.0	1.5	0.07	0.08

A = Porthcawl Rd (N) B = Heol-Y-Splot C = A4229 (S) D = A4229 (N)

The results of the ARCADY assessment confirm that under the peak traffic conditions considered with the cumulative impact of Grove Quarry being reopened, the Smokey Cottage roundabout operates efficiently. The maximum Ratio of Flow to Capacity (RFC) of 0.609 compares favourably with the desirable maximum of 0.85, which itself retains a 15% reserve capacity below the RFC of 1.0 at which the theoretical capacity is reached.

It is also apparent that there are no significant queues or delays forming on any of the approaches to the roundabout during the peak hour periods considered.

By comparing the results above with those obtained without Grove Quarry being operational for mineral extraction, it is apparent that there is a slight increase in the RFC and also some queue lengths during the peak hours. However, this is to be expected with an increase in traffic and the variations are insignificant.

It is also noted that the average daily HGV flows associated with Grove Quarry fall within the range observed at Cornelly Quarry. It is therefore apparent that the increased HGV activity associated with the resumption of extraction at Grove Quarry would fall within existing day to day variations along both Heol-Y-Splot and the wider highway network.

11.9 Recommendations

Having considered the findings of the review and assessment undertaken, it is recommended that the existing traffic management protocols be maintained and reviewed in accordance with normal procedures during the remaining life of the development to ensure its impact is maintained at an acceptable level for the forthcoming review period.

It is also recommended that the vegetation to the south of the Gaens Quarry access be trimmed to improve visibility and that the surface of the access bellmouth be repaired to fill in the existing potholes to prevent the pooling of water, which contributes to dirt being splashed onto the highway. These minor maintenance issues should be the subject of continuous review throughout the life of the project as part of appropriate site management.

11.10 Planning Conditions

The existing planning permission has been implemented without resulting in unacceptable highway and transport impacts. Given that there are no highway-related conditions imposed on the existing planning permission, and that proposed development will not increase HGV activity on the road network when compared with the existing baseline scenario, no planning conditions are considered to be necessary or are recommended at this time.

11.11 Summary

The impact on the local highway network of the ongoing development at Gaens Quarry as part of the ROMP process has considered the extant planning permission and the implications of the proposed activities going forward.

The proposals effectively represent a continuation of current activities as the proposed hours of operation, method of transport and types of vehicle used also accord with the extant planning permission; as does the proposed access arrangement, which will continue to utilise the existing access point to Porthcawl Road.

The existing access has been reviewed and was found to be acceptable.

The safety performance of the site accesses and local highway network, which continue to accommodate daily HGV movements, has been reviewed using collision records obtained from the Council. The records confirm that there have been no recorded accidents at the accesses and no recorded accidents involving HGVs on the neighbouring highway network.

The typical rate of extraction would result in an average of 31 loads/62 HGV movements per day on the local road network.

In accordance with the ongoing and historic operations, the majority of HGVs travelling to/from the site would travel via the A4229 to the north towards the Junction 37 of the M4.

To consider the impact of activities at Gaens Quarry, new traffic surveys were undertaken which revealed the local highway network retains significant levels of reserve capacity both under existing conditions and cumulatively should extraction recommence at Grove Quarry, which is currently mothballed.

The reserve or spare capacity of Porthcawl Road was found to be 1597 vehicles, or 84% of its design flow during the busiest hour. Similarly, the demand on the A4229 was found to be approximately 1000 vehicles, or 40% of its design flow under peak hour conditions. The Smokey Cottage roundabout was also found to retain a reserve margin of more than 30% before its design capacity is reached. As a result, highway capacity is not considered to be a constraint to the ongoing development.

11.12 Conclusions

Following completion of the review of the highway and transport implications of the proposed development it is concluded that:

(i) The site access is acceptable, subject to routine maintenance;
(ii) The local road network has substantial spare design capacity, and can accommodate the quarry traffic without difficulty, including the additional traffic associated with Grove Quarry, should mineral extraction recommence at that site; and

(iii) There are no recent records of accidents involving HGV's in the vicinity of the quarry, and, overall, the local highway network enjoys a good safety record; and

Accordingly it is concluded that the development proposed under this ROMP review is acceptable in terms of highway and transport matters.

12.0 CULTURAL HERITAGE

12.1 Introduction

This chapter of the ES contains the results of a cultural heritage desk study and impact assessment of the proposed scheme on the historic environment, prepared in support of the ROMP Review. While the Scoping Direction issued by the Welsh Government in March 2013 did not stipulate that a cultural heritage assessment would be required as part of the ES, a scoping opinion provided by the former Countryside Council for Wales in June 2010 drew attention to the proximity of the site to two registered landscapes of historic interest, and stated that the ES should consider any changes at Gaens Quarry in relation to these assets. This chapter addresses this specific issue, alongside the heritage resource at the site and the surrounding area.

The desk study and impact assessment considers both designated and undesignated historic assets which include the following:

- world heritage sites
- scheduled monuments
- listed buildings
- historic parks and gardens
- registered historic landscapes
- undesignated archaeological remains and sites, for example those recorded by the regional Historic Environment Record (HER).

Impacts in terms of cultural heritage may be direct (for example the physical removal of archaeological remains) or indirect (for example the impact of a scheme on the settings of nearby designated heritage assets). Impacts may be beneficial or detrimental, and short-term, long-term or irreversible.

12.2 Methodology

12.2.1 Guidance and Industry Best Practice

This chapter refers to the following guidance (a short title used to refer to the relevant document in this section is provided after each reference):

- Planning Policy Wales Chapter 6 Conserving the Historic Environment (Welsh Government 2014) (PPW Ch 6);
- Conservation Principles for the Sustainable Management of the Historic Environment in Wales (Cadw 2011) ('Conservation Principles');
- Guide to Good Practice on using the Register of Landscapes of Historic Interest in Wales in the Planning and Development Process (Cadw 2007) ('Landscapes Guide'); and
- The Setting of Heritage Assets: English Heritage Guidance[26] (English Heritage 2011) ('EH Settings').

SLR Consulting Limited is a Registered Organisation with the Institute for Archaeologists (IfA). Where relevant this chapter has been prepared with reference to the IfA's *Standard and Guidance*

[26] Deemed to apply in Wales in the absence of specific national guidance

for Historic Environment Desk Based Assessment[27] and Glamorgan Gwent Archaeological Trust's '*Notes for archaeologists undertaking desk based studies*'.

12.2.2 Assessment Approach

The Chapter is organised in the following main sections:

- baseline conditions, derived from a desk based assessment of the sources described below;
- assessment of the importance of the cultural heritage and archaeological resource;
- assessment of the impact of the scheme on the cultural heritage and archaeological resource;
- residual impacts; and
- conclusion.

There are 2 appendices to this Chapter:

- Appendix 13A Cultural Heritage Impact Assessment Methodology
- Appendix 13B Gazetteer of Heritage Assets

12.2.3 Sources of Information

The baseline data used in this chapter has been derived from:

- designated heritage assets data maintained by Cadw;
- the online 'Coflein' database maintained by the Royal Commission on the Ancient and Historic Monuments of Wales (RCAHMW);
- Glamorgan Gwent Archaeological Trust Historic Environment Record (GGAT HER);
- Historic Landscape Characterisation data held by GGAT;
- historic mapping;
- geological mapping;
- aerial photography;
- zone of theoretical visibility (ZTV) modelling prepared for the Landscape and Visual Impact Assessment (Chapter 6);
- current Ordnance Survey mapping; and
- published sources on archaeology and history.

12.2.4 The Study Area

A study area consisting of all land within 1km of the site boundary has been considered for the collection of baseline data relating to non-designated heritage assets.

In the *Baseline Conditions* section, non-designated heritage assets recorded by the GGAT HER are referred to in the text by their HER reference number, prefixed 'PRN'.

Data relating to designated heritage assets has been considered up to 5km for those assets falling within the ZTV of the existing quarry and proposed scheme.

[27] Institute for Archaeologists (2011)

12.2.5 Assessment Criteria

This assessment draws upon information on the historic environment for the site and its surroundings gathered from the sources described above.

The information has been collated and described in the Baseline Conditions section below, with known and potential historic assets identified.

In undertaking the impact assessment, the nature of the scheme has been considered, particularly with reference to potential below-ground impacts ("direct impacts") and visual impacts ("indirect impacts").

The assessment incorporates data on potential visual impacts determined in the course of the Landscape and Visual Impact Assessment (Chapter 6), and should be read in conjunction with that chapter.

Impacts are characterised in terms of their extent, duration and reversibility. To determine a measurement of the *Significance of Impact*, the "Magnitude of Impact" is combined with consideration of the "Importance of Asset" using an impact matrix (see Appendix 13A for full methodology and definitions). After consideration of any proposals for mitigation, the residual effect is stated.

12.2.6 Declarations, Legislation and Planning Policy

International Declarations and Directives

The European Directive regarding EIA requires appropriate identification, description and assessment of the direct and indirect impacts of developments on a number of aspects of the environment, including human beings, landscape, material assets and cultural heritage, and the interaction between them.[28]

The importance of protecting the setting of heritage structures, sites or areas is recognised internationally in various declarations and directives. Appendix E of the Directive includes the requirement that consideration of effects on cultural heritage features should include visual effects on the surrounding area, visitor and resident populations and landscape. The Xi'an Declaration[29] deals specifically with conservation of settings of heritage assets and was adopted by the participants of the 15th General Assembly. It includes acknowledgement of the contribution made by setting to the significance of heritage monuments, sites and areas.

Legislation

Scheduled monuments in Wales are protected under the Ancient Monument and Archaeological Areas Act 1979. Cadw maintains and compiles the list on behalf of Welsh Ministers[30].

---

[28] European Parliament 2011: *Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the Assessment of the Effects of Certain Public and Private Projects on the Environment,* Article 3. In a similar list (of information required set out in Annex IV.3), effects are required to be significant, and 'cultural heritage' is replaced by 'the architectural and archaeological heritage'.

[29] International Council on Monuments and Sites (ICOMOS): *Xi'an Declaration on the Conservation of the Setting of Heritage Structures, Sites and Areas* (2005).

[30] non-statutory criteria for scheduling are set out in Circular 60/96 Planning and the Historic Environment – Archaeology.

Historic buildings and areas are protected under the Planning (Listed Buildings and Conservation Areas) Act 1990. This list is also compiled and maintained by Cadw on behalf of Welsh Ministers[31].

Cadw has compiled a non-statutory Register of Landscapes, Parks and Gardens of Special Historic Interest in Wales. These are a material consideration within the planning system. Guidelines on assessing the impact of development on historic landscape areas (ASIDOHL2) is given in Cadw (2007) *Guide to Good Practice on using the Register of Landscapes of Historic Interest in Wales in the Planning and Development Process*. The guide also assists local planning authorities in deciding how much weight to give information in the register when determining planning applications.

National Planning Policy and Circulars

Planning Policy Wales, Chapter 6 (PPW Ch 6): Conserving the Historic Environment outlines Welsh Government planning policy on the historic environment in terms of the preparation of Local Development Plans, decisions on applications for planning consent, conservation area consent and listed building consent. In terms of the setting of assets included in the Register of Landscapes, Parks and Gardens (second part), it is noted that local planning authorities should consider the implications of development which, due to their scale, have a *more than local impact on an area in the Register* (6.5.25).

With regard to archaeological remains PPW Ch 6 notes that in cases involving archaeology of lesser importance, local authorities will need to weigh the relative importance of the archaeology against other factors including the need for the development (paragraph 6.5.1). It is advised that consultation is undertaken with the local authority, and if important remains are thought to exist that field evaluation is carried out (6.5.2). Investigation and recording of remains deemed to be of lesser importance should be secured by the developer prior to development where preservation in situ is not justified (6.5.3).

Circular 60/96 Planning and the Historic Environment: Archaeology and Circular 61/96: Planning and the Historic Environment: Historic Buildings contain advice on legislation and procedures relating to archaeological remains and historic buildings and conservation areas respectively. Circular 60/96, which is relevant to this assessment, notes that developers and local authorities should take into account archaeological considerations and deal with them as part of the development control process (paragraph 10). It advises early consultation, desk based assessment and where necessary field evaluation. Where remains of lesser importance are involved, preservation by record can be secured by condition of consent for development (paragraph 18).

Cadw's *Conservation Principles for the sustainable management of the historic environment in Wales* provides an approach for making decisions about all aspects of the historic environment. It is broadly based on English Heritage's Conservation Principles (2008) and draws on terminology from that document. The document sets out core principles and definitions, considerations for assessment and management of heritage resources. With regard to the archaeological resource it is noted that the material loss of evidence through archaeological intervention would normally only be acceptable if it is demonstrated that any increase in knowledge outweighs the loss of the resource (p 24).

[31] The criteria for listing are set out in Circular 61/96 Planning and the Historic Environment: Historic Buildings and Conservation Areas and Circular 1/98 Planning and the Historic Environment: Directions by the Secretary of State for Wales.

Local Planning Policy

The Bridgend Local Development Plan (adopted September 2013) contains policies on the protection and enhancement of historic assets. Strategic Policy SP5 (Conservation of the built and historic environment) states that development should conserve, preserve or enhance the built and historic environment, and that development would not be permitted where significant impacts were predicted on listed buildings, conservation areas, scheduled monuments, significant archaeological sites, historic landscapes, parks and gardens, locally significant buildings or the settings of any of these assets.

12.2.7 Consultations

In undertaking this assessment the Glamorgan Gwent Archaeological Trust has been consulted (15th January 2014) to obtain data on undesignated assets in the study area and specific data relating to historic landscape character areas within the adjacent registered historic landscapes.

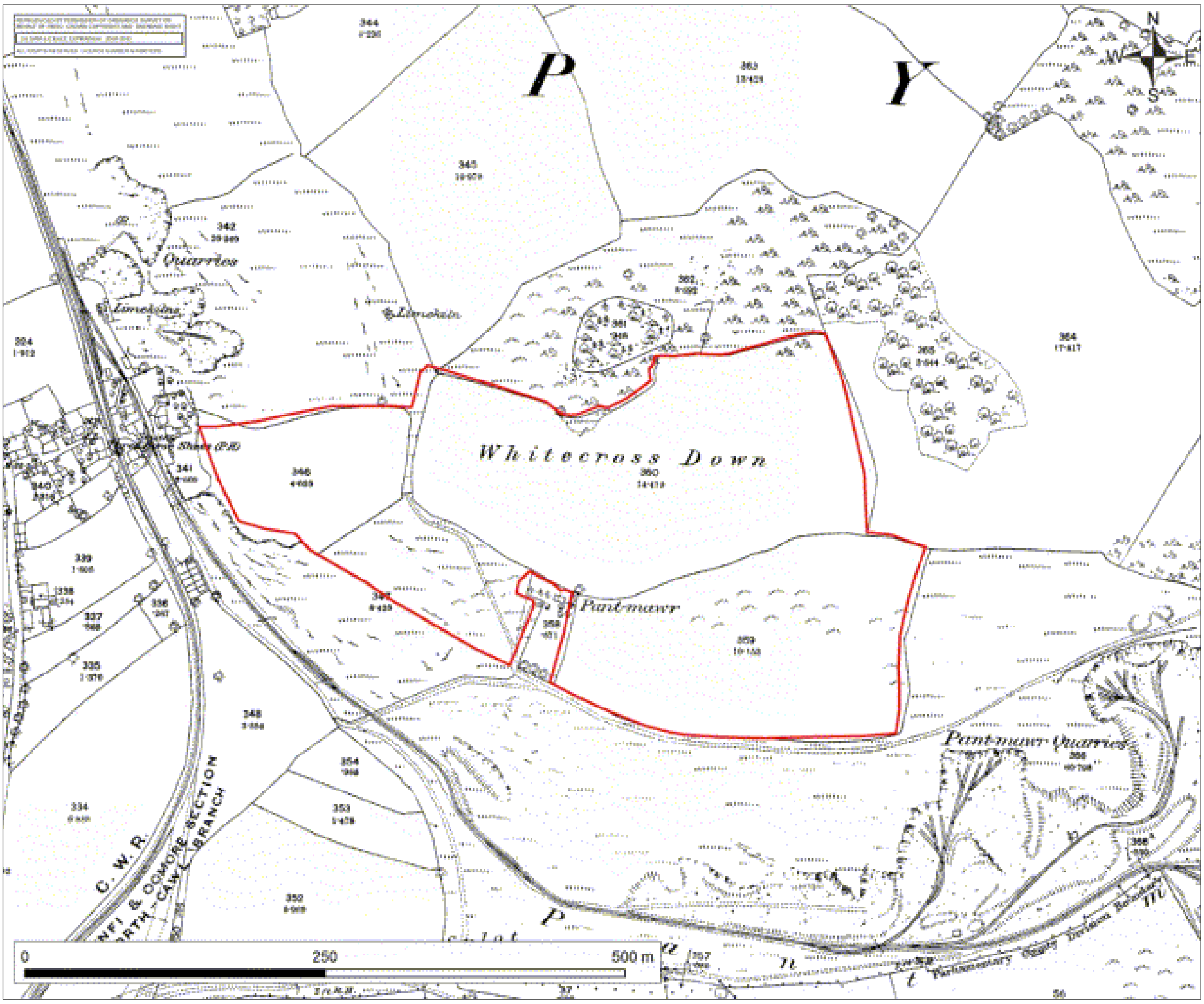
12.3 Baseline Conditions

12.3.1 Landscape Evolution within the Site Boundary

The area of Gaens Quarry to which this ES relates comprises an area of 12.72 ha, with extraction of limestone from the underlying Oxwich Head Limestone Formation bedrock. The BGS holds no information on drift geology at the site, with the majority of the land within the application boundary recorded as artificial (*i.e*. it has been removed by quarrying).

Historic mapping indicates that during the late 19th century (1877 1:2,500 OS(Figure 12-1) the land within the site was in agricultural usage. The site spanned four former parcels of land, Whitecross Down being the largest to the north and north east. Smaller fields were present to the south and west, with the OS data indicating a mixture of rough and improved pasture. These fields appear to have been enclosed as larger blocks of upland pasture in contrast to some remnant medieval strip fields evident on lower ground surrounding South Cornelly. A break in the southern site boundary corresponds with the location of Pant-mawr house which has since been demolished. A topographic high point to the north of the site was tree covered, and a stand of deciduous woodland was present to the north east of the site. Local quarrying was already quite extensive to the south east of the site (‘Pant-mawr Quarries’), a tram/rail link providing connection to the Llynfi & Ogmore Section of the Porth Cawl Branch railway which ran northwards to the west of the site. Smaller unnamed quarries and lime kilns are indicated to the north west of the site which would later become Gaens.

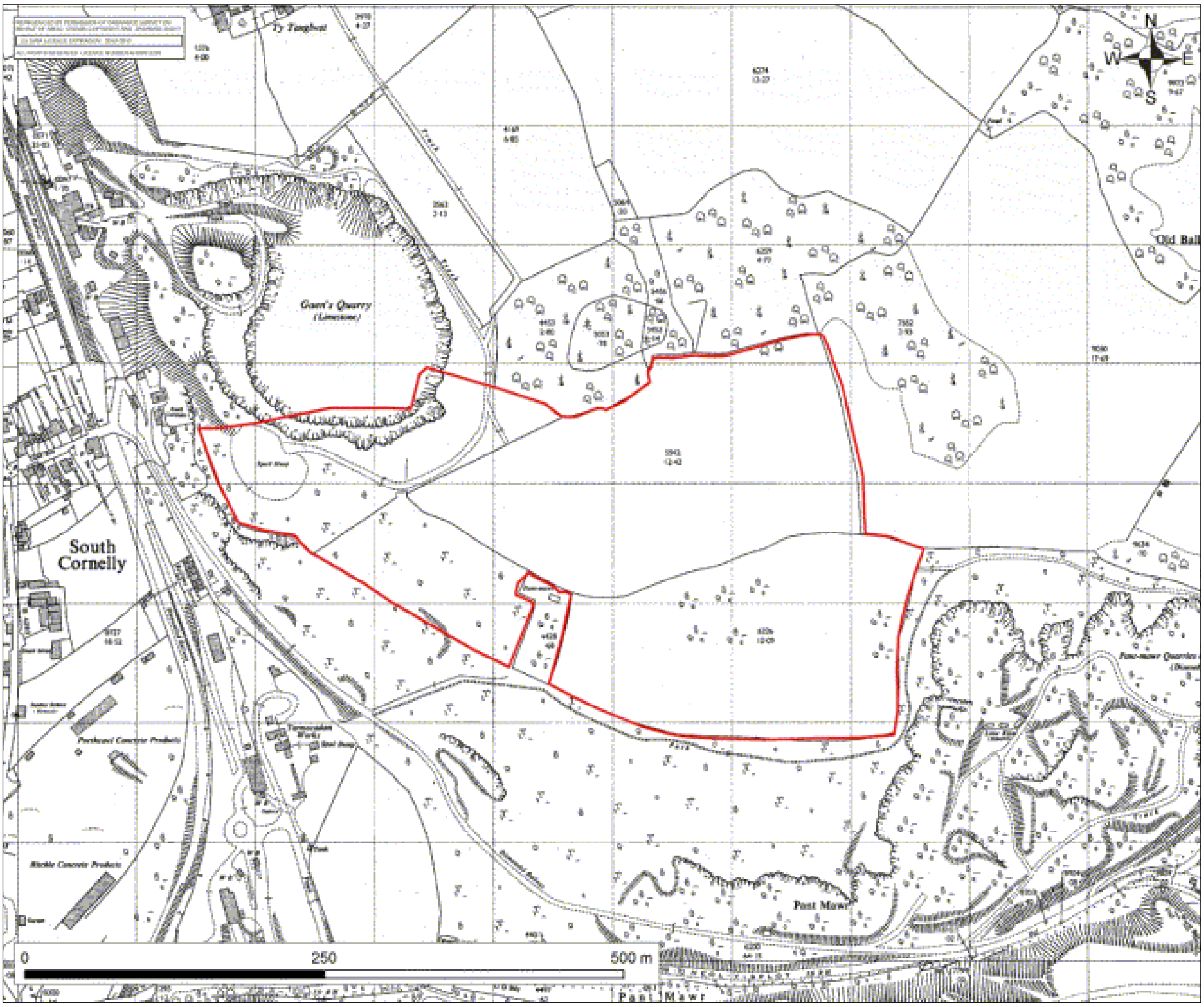
Figure 12-1
1877 Ordnance Survey map (1:2,500), Gaens ROMP boundary in red outline



The conditions within the site boundary remained unchanged in 1899, 1919, 1942 and 1965, while Pant-mawr and Gaens Quarries continued to expand in size ('Gaens' was first indicated by name on the 1942 1:2,500 OS map).

Encroachment of the quarry into the site first appears in the mapping in 1966 (occurring between the surveys for the 1965 1:10,560 OS map and the 1966 1:2,500 OS), with a portion of Gaens Quarry coinciding with the north west extent of the site, and a large spoil heap 70m in diameter positioned in the western corner with a connecting track between the quarry face and spoil heap.

Figure 12-2
1966 Ordnance Survey map (1:2,500), Gaens ROMP boundary in red outline



By 1988 the 1:2500 OS indicates that all land within the site boundary had been worked with the exception of a 30-50m wide strip along the south west edge, with cliffs flanking the base of the quarry workings.

12.3.2 Archaeological Potential within the site and study area

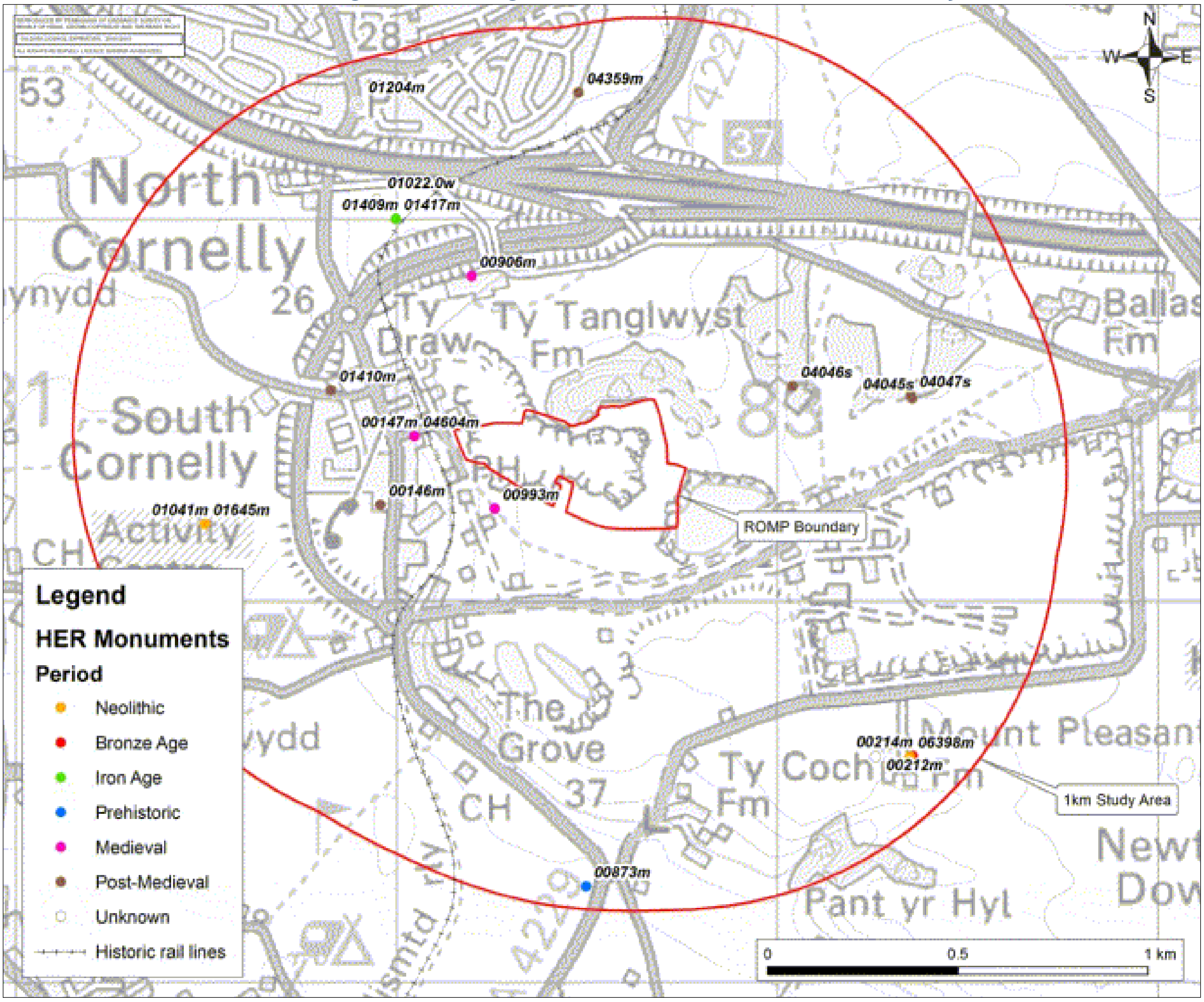
There are no recorded heritage assets within the site boundary.

The Glamorgan Gwent Archaeological Trust HER records 20 non designated heritage assets within 1km of the site. These predominantly reflect prehistoric and medieval activity, though post-medieval activity is also recorded.

The most significant local prehistoric site is located at Mount Pleasant Farm 0.87km south east of the site boundary. Excavation of a supposed cairnfield in 1952 in advance of a proposal for quarrying proved that the earthwork features were not of prehistoric date (PRN 00212m), however in the course of the investigations a plough-damaged Bronze Age barrow was identified (PRN 00214m), and a Neolithic hut (PRN 06398m). The Museum of Wales holds 9 objects comprising Neolithic – Bronze Age pottery sherds and stone implements associated with these investigations.

Land surrounding Ty Draw Farm 0.7km west of the site contains findspots of Neolithic/Bronze Age artefacts, including a polished stone axe and a barbed-and-tanged arrowhead (PRNs 01041m, 01645m). There are also findspots of an Iron Age coin (PRN 01417m) 0.58km north of the site, and a range of finds including a prehistoric flint scraper and Romano-British pottery 0.95km to the south (PRN 00873m).

Figure 12-3
Non designated heritage assets within 1km of Gaens Quarry



There are 5 medieval assets within the study area, all associated with religious/funerary activity. The Church of St Cornelius in South Cornelly (PRN 00147m) was a chapel located around 118m from the site's western end, while St Thomas' Chapel was located 0.57km to the north (PRN 01409m). The condition of these assets is unknown. A cross was indicated on Rees' map of Wales in the 14th century somewhere approximately 0.1km from the site's south west boundary, but no trace of it survives today (PRN 00993m). A possible grange is indicated from documentary sources at Ty Tanglwyst Farm to the north of the site (PRN 00906m), while two human interments were discovered at Rock Cottages 100m west of the site in South Cornelly during building work (PRN 04604m).

Post medieval assets recorded in the study area include Old Ballas Quarry and Tanglwyst Quarry and Limekiln (PRNs 0406s and 04047s/04045s), the dismantled Llynfi & Ogmore Section of the

Porth Cawl Branch railway (PRN 04359m), and Ty-Maen and Ty Draw houses (PRNs 00146m and 01410m).

There are two undated assets in the study area, including a possible sunken trackway (PRN 01022.0w) 0.66km north of the site at Pyle and an area of ridge and furrow ploughing which may be medieval or early post-medieval in date 0.9km north of the site at North Cornelly (PRN 01204m).

Recorded archaeological 'events' within the study area comprise 10 individual interventions at Mount Pleasant Farm, including field visits and excavations dating back to 1951 and a historic building survey, a watching brief at Ty Maen house in 2000, an archaeological desk study relating to North Cornelly prepared by Wessex Archaeology in 2002, and a salvage excavation at the Church of St Cornelius, South Cornelly, undertaken by GGAT in 1982.

12.3.3 Designated assets surrounding the site

Within 1km of the site there are 2 Grade II listed buildings situated on Porthcawl Road to the west. These comprise Ty-maen house and its garden gateway. There is no view or clear aspect towards the site from these buildings. Approximately 1.2km to the north of the site within North Cornelly there are 2 Grade II* listed buildings, comprising The Hall Farm and Pyle Calvinistic Methodist Chapel.

The nearest historic park and garden is the Grade II Tythegston Court 2.6km to the south east. This is a late 18th to 19th century landscaped park and garden. The setting of the park extends northwards from the core of the gardens, with significant views identified to the north/ north east.

The nearest scheduled monuments to the site are located 2.5km from the site boundary. They comprise Dan-y-Graig Roman villa to the south east, Mynydd Herbert Round Barrow to the east, Stormy Castle medieval motte to the north east and Pyle incised stone/Leat and dam at Llanmihangel Mill to the north. Merthyr Mawr Warren lies 3.9km to the south east while Kenfig Castle and medieval town lies 2.8km to the north west.

There are two registered landscapes of historic interest in the general area of the site. The first of these, Merthyr Mawr, Kenfig and Margam Burrows is designated as a Landscape of Outstanding Historic Interest. The designated area falls into two discrete zones, with Merthyr Mawr Warren situated 3.1km to the south east of the site at its nearest point, and Kenfig and Margam Burrows situated 2km to the north west.

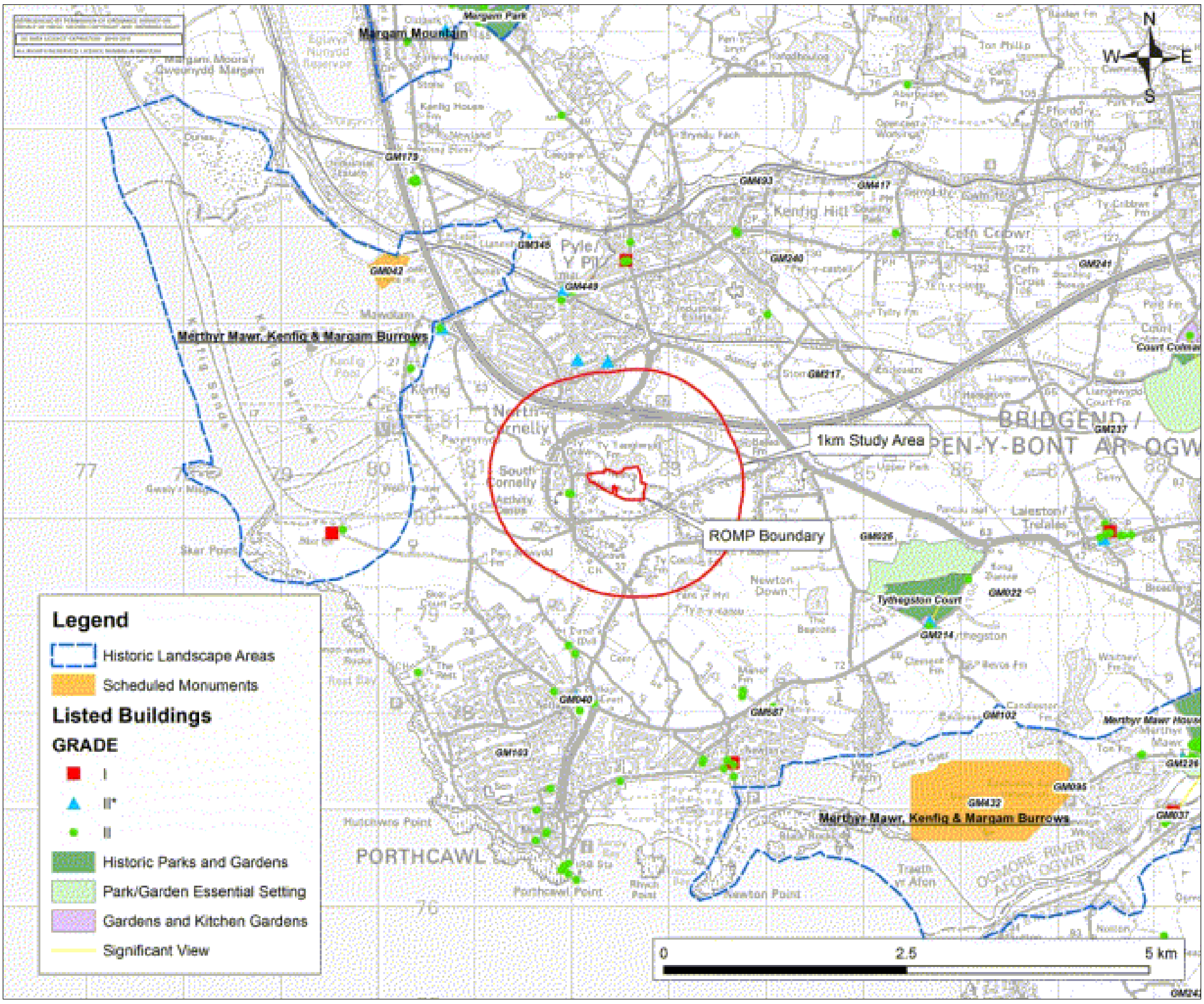
Merthyr Mawr Warren lies on the north west side of the River Ogmore estuary with coastal dunes reaching heights of 80m AOD. The movement, erosion and re-deposition of the dunes has led to the discovery of a range of highly significant buried archaeological features within the area, including Mesolithic, Neolithic, Early Bronze Age, Iron Age and medieval occupation sites all represented. The dunes have encroached upon the late 14th century Candleston Castle, the lands of which are now buried beneath the sand. Merthyr Mawr village may have had an early medieval origin as a Monastic Clas based on early Christian stones in the church.

Kenfig and Margam Burrows is positioned on the coastal plain to the south of Margam Mountain. The extensive dune system overlies the castle and medieval borough of Kenfig (which is designated as a scheduled monument), a Norman foundation but with evidence for earlier occupation in the prehistoric, Roman and early medieval periods. Kenfig Castle (which is now buried within the dunes) occupied a strategic position at the head of the River Cynffig Estuary in the approximate location of the Roman road from Cardiff to Neath, which was later used in the medieval period. The settlement surrounding Kenfig Castle was large (with a population of 700-

800), but was essentially abandoned by the late 15th century as sand encroachment enveloped the settlement.

The second registered historic landscape is Margam Mountain, around 4.5km to the north of the site. This is designated as a Landscape of Special Historic Interest. This extensive zone includes the flanks, plateau and highest point of Margam Mountain. The southern extent of the designated area is bounded by the valley of the River Cynffig and overlooks the coastal plain and M4 motorway corridor. The southern limit of Margam Mountain was a strategic position, restricting principal communications routes between east and west in earlier periods to the coastal plain. Human activity recorded includes scattered Bronze Age ritual/funerary activity, Iron Age hill forts, enclosures and trackways, the Roman road and milestones, and early medieval reoccupation of hill forts and establishment of religious/Early Christian sites. Medieval activity comprising the establishment of Llanynwyd Castle to the east and an administrative centre at Tir Iarll reflected the continued strategic importance of this landscape.

Figure 12-4
Designated heritage assets surrounding Gaens Quarry



12.3.4 Summary

Until the latter half of the 20th century the land within the site was predominantly agricultural. Quarrying expanded into the site over a period of 20 years between the later 1960s and 1980s, eventually removing the majority of surface deposits down to bedrock with the exception of a strip of land along the south west boundary. The current quarry falls within a wider zone of mineral extraction to the east of South Cornelly.

Because of its topographic location surrounded by a wooded ridge, and in part also due to the rolling character of the surrounding countryside, the working area of Gaens is not readily visible from the surrounding landscape with the exception of the existing southern quarry tip.

The evidence for archaeological activity in the area suggests that local sites were favoured for settlement, subsistence and ritual/funerary activity from the Neolithic period onwards. South Cornelly has medieval origins, with strip fields surrounding the small settlement focussed around the Church of St Cornelius. Managed farmland does not appear to have extended up on to the ridge occupied by the quarry, however it is likely that the area later known as Whitecross Down was used as seasonal pasture.

Within the site there is no potential for surviving archaeological remains where quarrying has occurred.

12.4 Direct Impacts

The proposed scheme comprises a total of four phases of extraction within the ROMP boundary, commencing with extraction in the eastern part of the quarry and extending to include the western half in Phase 3, ands a final zone of extraction in the south east corner of the quarry in Phase 4.

Due to the widespread truncation of surface deposits at the site, there are no predicted direct impacts which would result from the development over the period covered by this ROMP in Phases 1, 2 or 4. The significance of effect would therefore be **Neutral**.

During Phase 3 the planned extraction includes an area of 0.45ha along the south west boundary which has not previously been worked based on the historic map evidence. This area is currently under tree cover. No known heritage assets are located in this area and it is not anticipated that significant unknown archaeological remains are likely to be present. Subsequent activity within the site, including plant movement and the establishment of dense tree cover is likely to have caused significant ground disturbance. If archaeological features are present these would be of **Unknown** importance, however as these would most likely relate to low intensity upland pasture land use and post medieval agricultural activity, it is suggested that such features would be of no more than **Low** importance. The impact of quarrying would lead to total and irreversible (*i.e.* permanent) loss of such features would be a **Major** magnitude of impact, resulting in a Slight/Moderate significance of effect overall.

12.5 Indirect Impacts

The ZTV model for the existing landform at Gaens Quarry indicates that the principal areas from which the quarry is theoretically visible are South Cornelly (at vertical angles of between 1^{o} and 3^{o}) and more widely from the north west and south west at low vertical angles of visibility (less than 1^{o}). Given the existing woodland surrounding the quarry, however, the true picture is in fact much reduced, and viewpoint photography included within Chapter 6 indicates that only the southern quarry tip is widely visible, the quarry faces being otherwise obscured.

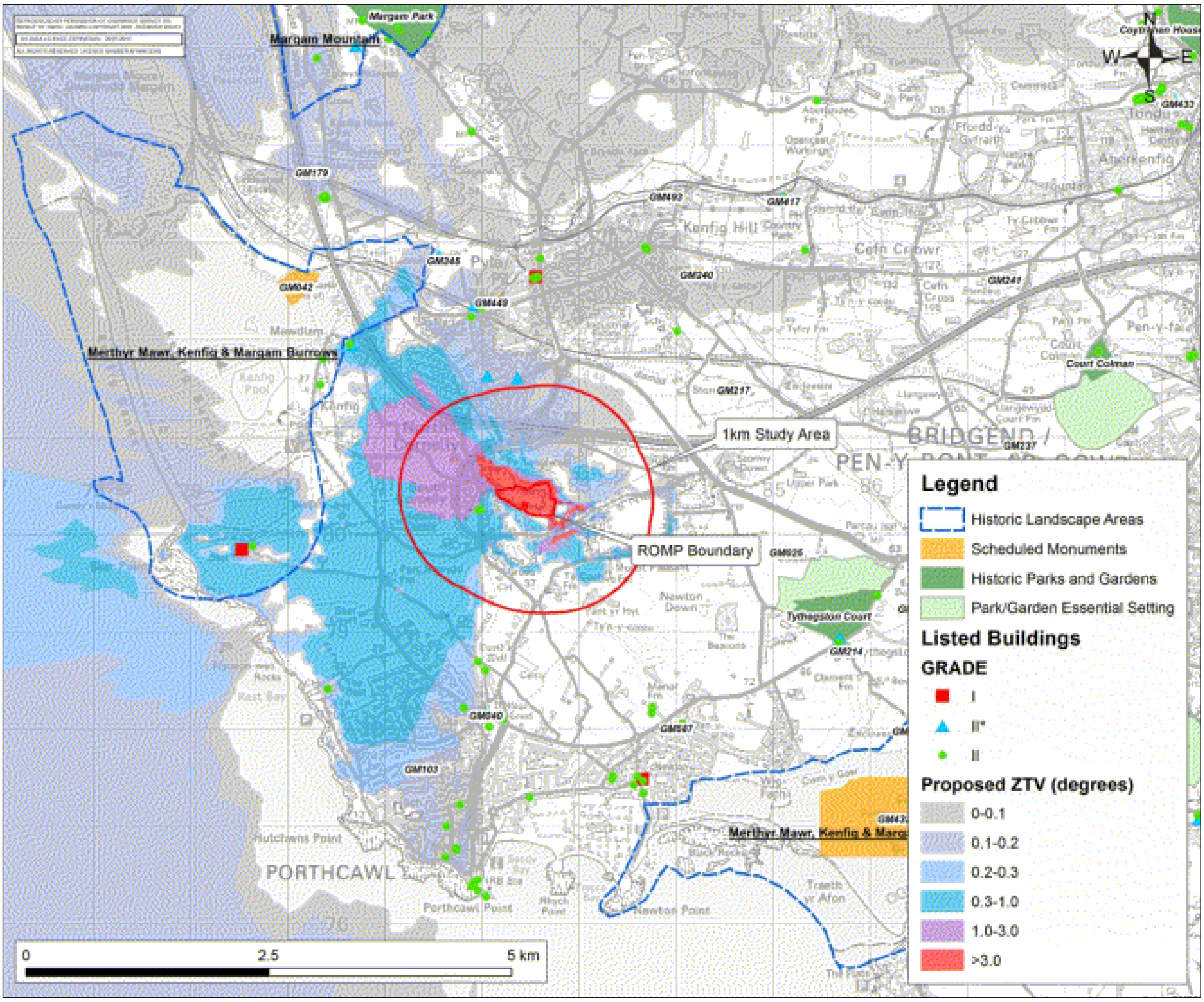
12.5.1 Registered Landscapes

Under the existing conditions there is no visibility of Gaens from within the designated area of Merthyr Mawr Warren. The ZTV for the proposed layout shows no change, therefore there is no potential impact on any of the individual character areas within the registered part of this landscape, a **Neutral** significance of impact on this asset.

From Kenfig and Margam Burrows Landscape of Outstanding Historic Interest the ZTV indicates that the existing quarry is theoretically visible at low vertical angles of less than 1^{o} and in excess of 1.8km from the southern portion of the landscape around Sker Point, and at very low angles of less than 0.2^{o} from the western part of Kenfig Sands and dunes of Margam Moors. Within this landscape and coincident with the ZTV there are two listed buildings- Sker House (Grade I) and Ty-yr-ychen (Grade II). These buildings are included in Viewpoint 11 (Chapter 6) which highlights that the woodland surrounding Gaens obscures the quarry from view, though the southern tip is visible as a skyline feature. The ZTV for proposed layout indicates a reduction in the visibility of the quarry from within the registered area, including reduced angles of visibility from the southern Margam Moors dune system, the western part of Kenfig Burrows and the area surrounding Sker House. This reduction in visibility would include a reduction in the size of the southern tip. Given the already low angles of visibility from these locations, any impact will be of minor magnitude and reflect a positive change to assets of high importance, a **Slight** and **Beneficial** significance of impact overall.

From Margam Mountain Landscape of Special Historic Interest the ZTV for the existing layout suggests that there is restricted visibility of the quarry at very low vertical angles of less than 0.2 or 0.1^{o}, 4.6km to the south from the Eglwys Nunydd and Cwrt y Defaid and Margam Abbey and Castle character areas. The latter is coincident with the boundary of Margam Park Grade I Historic Park and Garden which also contains listed buildings associated with the kitchen garden, lodges and a barn at Eglwys Nunydd. The obscuring effect of intervening buildings and vegetation restricts any visibility of the quarry from these locations. The ZTV for proposed layout indicates that the theoretical visibility of the quarry will be reduced further, notably from the south west part of the Eglwys Nunydd historic landscape character area. The magnitude of impact is likely to be neutral or minor and positive on assets of medium to high value, overall suggesting that the significance of impact will be **Neutral** to **Slight** and **Beneficial**.

Figure 12-5
Designated heritage assets surrounding Gaens Quarry with reference to ZTV for the proposed scheme (ZTV zones of visible vertivcal angle are measured in degrees)



12.5.2 Scheduled Monuments

The ZTV for the existing layout suggests that the quarry is visible from 6 scheduled monuments in the surrounding landscape. The potential impacts on the setting of these assets are summarised in Table 12-1 below. Overall no change (**Neutral** impact) is predicted on all monuments with the exception of Pen-y-Castell Camp from which a slight reduction in visibility of the quarry tip will result in a **Slight** and **Beneficial** significance of impact on the monument's wider landscape setting.

Table 12-12-1: Summary of Impacts on setting of Scheduled Monuments within ZTV

Scheduled Monument Number	Name	Type	General Period	Easting	Northing	Distance from site	Existing ZTV	Current Setting	Proposed ZTV	Predicted Impact
GM179	Ty'n-y-Cellar Standing Stone	Standing stone	Prehistoric	280245	183740	3.8km	0.2-0.3	Adjacent to raised M4 corridor with vegetation to south, no visibility of site.	0.1-0.2	No Change-Neutral
GM449	Leat & Dam at Llanmihangel Mill	Leat	Post-Medieval/ Modern	282087	182400	1.9km	0-0.1	Leat in wooded belt behind buildings west of Pyle, no visibility of site	0-0.1	No Change-Neutral
GM036	Pyle Incised Stone	Cross-marked stone	Medieval	282240	182325	1.8km	0-0.1	In front garden of 20th century house with no visibility of site	0-0.1	No Change-Neutral
GM240	Pen-y-Castell Camp	Hillfort	Prehistoric	284226	182689	2.6km	0.1-0.2	Prominent position in farmland east of Pyle. View towards site across residential development. Oversailed by electricity transmission lines.	0-0.1	Slight reduction in visibility of quarry tip- Slight and beneficial significance of impact.
GM103	Hutchwns round barrow	Round barrow	Prehistoric	281377	177606	2.8km	0.1-0.2	Within a housing estate backed onto by bungalows. No visibility of site	0.1-0.2	No Change-Neutral
GM241	Cefn Cross Standing Stone	Standing stone	Prehistoric	287390	182636	5.1km	0-0.1	Adjacent to farm track within wooded enclosure, no clear visibility of site.	Not visible	Neutral

12.5.3 Listed Buildings

In addition to the listed buildings noted in section 13.5.1 above that are within registered historic landscapes, the ZTV for the proposed layout indicates that there are 34 listed buildings within 5km from which the final phase development would be visible. These buildings fall into discrete areas, with 2 in South Cornelly, 14 in North Cornelly/Pyle, 2 in Mawdlam (Pyle with Kenfig), 12 in Porthcawl and a cluster of 4 at Ty'n y Cellar.

Of these buildings, those most sensitive to changes in their setting are the Grade I listed Church of St James (Pyle with Kenfig) and Grade II* listed Church of St Mary Magdalen (Pyle with Kenfig) which occupy prominent, open positions from which their landscape setting forms an essential component. In both cases views towards the development are obscured by housing, and there would be no perceptible change within their setting, a **Neutral** significance of impact. This also applies to Grade II listed monuments with the respective churchyards.

Neutral impacts are predicted for the Grade II* listed Hall Farm and Llanmihangel Mill, North Cornelly, which despite theoretical visibility of the development are in fact embedded within modern housing developments.

The Pyle Calvinistic Methodist Chapel is Grade II* listed and has open views southwards across the built up area of North Cornelly towards Gaens Quarry. The existing southern quarry tip is visible within this view at low angles of between 0.1-0.2°. The ZTV for the final layout indicates no change to this angle of visibility, though the southern tip would appear reduced in scale. However it is considered that visibility of the tip does not adversely affect the heritage significance of the building, which draws its value principally from its association with the surrounding settlement. The significance of impact would be **Neutral** to **Slight** and **Beneficial**.

Two Grade II listed buildings fall within the ZTV for the proposed layout within South Cornelly; Ty Maen house and its garden gateway are listed independently, 0.25km west of the application boundary. The ZTV indicates that both the existing and proposed layouts would be visible at between 0.3-1.0^{o}, though any view of the quarry from the Porthcawl Road is obscured by woodland on the flanks of the quarry. No impact is predicted on these building, a **Neutral** significance of impact.

Four Grade II listed buildings are associated with Ty'n y Cellar farm. Dominant views from this farmstead (which operates as a bed and breakfast) are east and north east towards Margam Mountain. To the west is the raised carriageway of the M4. Any visibility of the quarry at low angles of 0.1-0.2^{o} will reduce to 0-0.1^{o} during the final phase of development. This change is likely to be imperceptible within the wider setting of the farmstead, a **Neutral** impact overall.

For the 12 listed buildings in Porthcawl, no impact would be anticipated. Where views out of the town or north from the breakwater area are possible, the slight reduction in visibility of the southern tip over a distance of 2-4km and at vsible vertical angles of less than 0.2^{o} suggests that the change would be barely perceptible within these settings and a **Neutral** impact overall.

12.6 Mitigation Measures

In relation to potential direct impacts on archaeological remains, there is a possibility that previously unrecorded features may be affected during the clearance and stripping of a previously unworked area along the south west boundary of the quarry (Phase 3). The archaeological advisors to the mineral planning authority (Glamorgan Gwent Archaeological Trust) may require archaeological mitigation to be undertaken during these works. Such measures may entail the removal of topsoil and subsoil under archaeological supervision as a strip map and record or watching brief exercise.

In relation to the predicted indirect impacts, no further mitigation measures are deemed to be required in addition to those proposed for landscape and visual purposes.

12.7 Residual Effects

Overall the residual effect of the scheme would be Neutral with regard to the historic environment, while localised slight beneficial impacts are noted where the visibility of the quarry tip is reduced over the four phases of the development.

12.8 Cumulative Effects

There would be no appreciable cumulative effects on surrounding heritage assets resulting from interaction with other quarry sites.

12.9 Conclusions

Based on the data gathered and assessed in this chapter, it is considered that there would be no significant impacts on known archaeological features, or indirect impacts on the setting of important assets in the surrounding area, resulting from implementation of the scheme under this ROMP review. This is consistent with policies on the protection of the historic environment, including Policy SP5 of the Bridgend Local Plan and national policies set out in PPW Ch 6, Circulars 60/96 and 61/96.

13.0 SUMMARY OF ENVIRONMENTAL EFFECTS

13.1 Introduction

The preceding chapters of the ES have assessed the effects of quarrying under a series of topic headings relating to environmental amenity issues. The exercise has identified a number of elements which require control and mitigation, and has highlighted up to date advice regarding standards and criteria.

As a summary of those issues, and by way of an introduction to schedule of updated planning conditions which will be prepared to accompany the final ES, the following key issues have emerged, which are reflected in the schedule of conditions.

13.2 Landscape and Visual Effects

13.2.1 LVIA Study

The purpose of the LVIA study is to evaluate the landscape and visual impacts associated with the proposed development, determine the likely effects to the landscape and visual character of the area, and make recommendations for mitigation measures which can be translated into planning conditions as part of the ROMP Review.

The Landscape and Visual Assessment covers the totality of the Gaens Quarry development, and considers the effects of the full quarry development scheme, including extraction, processing, access, quarry waste disposal etc. It also includes an assessment of the potential for cumulative landscape and visual effects associated with quarrying activities associated with Grove and Gaens Quarries that abut the site.

The assessment considers the sources of effects during the quarry operational and restoration stages, and the nature of effects ranging from neutral to very large. Consideration is then given to the type of effect in terms of both susceptibility to change and the value of the landscape, with a scale of effect ranging from very low to very high. The effects are considered in terms of whether they are direct or indirect, and the timescale of the effects. The final element of the assessment is to consider the significance of the effects with a correlation between the nature / magnitude of effects against the sensitivity of the landscape / visual receptor, based upon a scale of neutral to substantial.

13.2.2 Landscape Impact

The Landscape Assessment process concluded that beyond the site perimeter, but in close proximity to the Site (less than 2km), Newton Down and Porthcawl Hinterland V&S Aspectswill potentially experience landscape effects from the development.

Based on the Newton Down and Porthcawl Hinterland Visual and Sensory Aspects being of Medium sensitivity and the magnitude of effect in close proximity to the Site being Very Low adverse, the proposed future development will at most cause Very Slight adverse significance of effects to the landscape character of the Newton Downand Porthcawl Hinterland Visual and Sensory Aspect during the Operational period.Following final restoration the magnitude of effect being Very Low beneficial, combined with the Aspects being of Medium sensitivity, the proposed future development in the long term will cause Minimal beneficial significance of effectsto these Visual and Sensory Aspects.

The Landscape Assessment process concluded that beyond the site perimeter, at distances greater than 2km, Porthcawl Hinterland, Kenfig Burrows, Kenfig Sands, and Newton Point V&S Aspects,as well as Kenfig Burrows and Porthcawl Coast SLAwill potentially experience landscape effects from the development.

Based on the Porthcawl Hinterland Visual and Sensory Aspect being of Medium sensitivity and the magnitude of effect at distances greater than 2kmfrom the Site to the west being Very Low beneficial, the proposed future development will at most cause Minimal beneficial significance of effects to the landscape character of the Porthcawl Hinterland Visual and Sensory Aspect during the Operational period.Following final restoration the magnitude of effect being Neutral, combined with the Aspect being of Medium sensitivity, the proposed future development in the long term will cause Neutral significance of effectsto thisVisual and Sensory Aspect.

Based on the Kenfig Burrows,Kenfig Sandsand Newton PointVisual and Sensory Aspectsbeing of High sensitivity and the magnitude of effect at distances greater than 2km from the Site to the west being Very Low beneficial, the proposed future development will at most cause Very Slight beneficial significance of effects to the landscape character of the Kenfig Burrows, Kenfig Sands and Newton Point Visual and Sensory Aspects during the Operational period. Following final restoration the magnitude of effect being Neutral, combined with the Aspects being of High sensitivity, the proposed future development in the long term will cause Neutral significance of effects to these Visual and Sensory Aspects.

Based on the Kenfig Burrows SLA being of High sensitivity and the magnitude of at distances greater than 2km from the Site to the west being Very Low beneficial, the proposed future development will at most cause Very Slight beneficial significance of effects to the landscape character of the Kenfig Burrows SLA during the Operational period. Following final restoration the magnitude of effect being Neutral, combined with the Aspects being of High sensitivity, the proposed future development in the long term will cause Neutral significance of effects to this SLA.

Based on the Porthcawl Coast SLA being of Medium sensitivity and the magnitude of at distances greater than 2km from the Site to the west being Very Low beneficial, the proposed future development will at most cause Minimal beneficial significance of effects to the landscape character of the Porthcawl Coast SLA during the Operational period. Following final restoration the magnitude of effect being Neutral, combined with the Aspects being of Medium sensitivity, the proposed future development in the long term will cause Neutral significance of effects to this SLA.

13.2.3 Visual Impact

The western and southwestern boundaries are formed either by an agricultural field or by a rising wooded scarp slope that falls away from the easement around previously worked faces or the large southern tip. The southern boundary of the site falls away into the valley feature associated with Heol-y-Splot road after which the landform rises again to form part of either the existing or proposed future workings associated with Grove Quarry. The northern boundary of the site consists of woodland or treebelts that either form a small isolated hillock which falls away more steeply as a localised scarp slope in proximity to Old Ballas Wood.

As a consequence the existing footprint of Gaens Quarry is generally well screened and enclosed by the existing landform and vegetation within the general landscape setting.

The future development includes the removal of the large and visually prominent tip on the southern boundary. This tip, as a 'built-in' mitigation measure, will be removed in the short to medium term (5-10 years). The proposed future extraction of minerals is generally confined to the currently disturbed area and includes extending laterally to the east south and west.

The southern lateral extension will occur in Phase 2, in the medium term, with the western and eastern extensions in the long term. The western lateral extension includes removing a small area of mature woodland associated with the edge of the scarp slope that falls away to the south/southwest. The eastern extension effectively removes the existing bluff that physically separates Gaens Quarry from the former Pant Mawr quarry void. This area includes areas that have naturally regenerated, which will be lost in the long term.

Future proposals also include for the partial infilling of the western half of the former quarry void with quarry waste (the IDO area) which is bounded to the north and south by woodland and tree belts. However, the raised nature of the area and the higher elevation of the back faces results in some of this area being relatively open to view to receptors to the west. This will also be the case when the area is partially infilled with quarry waste.

Desktop studies collaborated by field work has identified that these areas are visible to the west and northwest, mainly between 0.5-1.0km from the site. The visibility of this tip and former quarry faces are increased by the light colour of these areas set against a dark green vegetated backcloth.

13.2.4 Landscape Mitigation measures

The following mitigation measures proposed therefore take these factors into account.

- Ensuring the limits of quarrying within the ROMP area avoids opening up the quarry to views from the west that would significantly affect local landscape character.
- Retaining the higher northern faces that have not been worked for a number of years which have weathered, so that following removal of the southern tip, faces that potentially become exposed to view are limited to these faces.
- Retaining the wooded southern and eastern flanks that are either wooded or are partly vegetated through natural regeneration as long as possible within the development to reduce a possible increase in landscape and visual effects from receptors to the west.
- Construction of a naturalistic screening bund along the southern boundary of the IDO area early within the development to screen tipping operations and possible vehicular movements from view to the west. The bund to be grass seeded and planted with native trees and shrubs to provide a vegetated visual barrier to views both in the short and long terms.
- Infill, widening and strengthening of the woodland belt along the western boundary of the proposed quarry void (adjacent to Lamb Row and Rock Cottages as well as adjacent to the weighbridge and offices) to help provide an additional visual barrier to potential views of the site when the existing trees are felled and the area is worked and ensure the long term survival of this visually important hedgerow/treebelt.
- Removal/relocation of the current southern tip early within the development and restoration of the lower slopes that are to remain by infill planting with trees and shrubs.
- Progressive working and restoration of the upper faces/benches both within the eastern void (ROMP area), as well as the future tipping operations within the western quarry

void as they reach final position by overtipping/natural recolonisation/tree and shrub planting/ grassland creation to create a more naturalistic landform and allow these areas to mature as early within the development as possible and minimise landscape and visual effects from receptors to the west.

13.2.5 Planning Conditions

In terms of landscape and visual matters the following key recommendations are suggested for inclusion within the ROMP Review to ensure the development meets current planning requirements and safeguards and enhances the areas landscape character and visual amenity both throughout the remaining operational life but also into the longer term following final restoration of the site.

- The Relocation and Restoration of the Existing Southern Tip and Restoration of the Retained Lower Slopes
- Formation of Screening Banks
- Proposed Hedgerow and Woodland Infilling and Planting
- Creation/Management, and Enhancement of Existing and Proposed Habitats in the Long Term

13.3 Ecology

13.3.1 Ecology Study

The study area was initially surveyed and assessed in detail by David Clements Ecology Ltd (DCE) in 2003, and was subsequently resurveyed in 2008 and 2013, using appropriate methods. The surveys were mainly based around the Extended Phase 1 survey methodology (see below), with some additional surveys for specific interests where these were considered necessary and practical. Information in support of this assessment is included at Appendices 6/1 to 6/10.

In accordance with a request from the WG, a Shadow AA has also been carried out by Atmos Consulting Ltd in parallel to this EcIA, to assess the effects of the continued operation of Gaens Quarry in conjunction with Cornelly Quarry and the currently mothballed Grove Quarry on Kenfig SAC. The Shadow AA is included in Technical Appendix 6/9 supporting this Chapter, which contain the supporting baseline information on the features of nature conservation interest on which this EcIA is based.

The consideration of the habitats and features of the study area are evaluated as follows:

- No sites of International or National Value have been identified in the study area.

- Lime Kiln Wood and the immediately adjacent scrub habitats have been identified as being of County Value. Most of this woodland lies off-site to the north.

- The southern and eastern quarry rim, comprising woodland, calcareous grassland, scrub, hedgerow and ephemeral/short perennial habitats have been collectively identified as being of District Value. There are also species-rich patches of ephemeral/short perennial habitats and neutral grassland in the north-west portion of the quarry; these are also considered to have District Value.

- The remaining ephemeral/short perennial and scrub habitats of the northern/western areas have been collectively identified as being of High Local Value.

- The lagoons and ephemeral/short perennial and scattered scrub habitats in the south have been identified as being of Local Value.

- The main working area of the quarry is considered to be of Negligible value for wildlife.

13.3.2 Ecology Impact

Impacts to protected species could potentially include loss or disturbance to nesting birds and reptiles; there may also be some potential for disruption to foraging badgers and bat roosts, although there is no evidence to date that the latter exist within the quarry area. Barbastelle, a rare species of bat, was recorded off-site to the east and is potentially roosting in Lime Kiln Woods. As discussed previously, negative effects on this woodland are considered to be unlikely and it is therefore considered that there will be negligible impact on barbastelle as a result of the development. While the cracks and crevices on the quarry faces could potentially be used by other species of bats, they are probably too heavily disturbed by the active quarry to have any value for use as roosts.

No nationally or regionally rare species would be affected, though there would be loss of feeding habitat for UK BAP Priority Species such as linnet and dunnock. There are also likely to be losses incurred by populations of a number of local plant species and invertebrates (including dingy skipper, a UK BAP Priority Species) as a result of the development.

Most of the affected species are likely to be able to find alternative habitat elsewhere in the study area. However, the impact on reptiles (especially in the south-eastern corner) could be significant as there are evidently breeding populations of common lizard and slow-worm on site; it is a statutory requirement that mitigation measures are set in place for these species.

On current information the potential for such impacts is estimated to be of Moderate conservation significance.

13.3.3 Mitigation Measures

These will comprise:

- Prior inspection of large trees and any large crevices in undisturbed areas of the quarry faces to check for possible bat presences immediately ahead of any tree-surgery or quarrying works, and implementation of a suitable protocol to ensure that any bats which are found are dealt with in accordance with current legislation and best practice.

- Trees generally will be treated in accordance with the guidance provided by the Bat Conservation Trust (BCT 1997, Bats and Trees: A Guide to the Management of Trees).

- A precautionary approach towards common reptiles will concentrate primarily on minimising the potential for causing the death and injury of individuals during site clearance. A full method statement with respect to reptiles should be prepared and agreed in advance with the Local Authority ecologist and NRW, prior to the commencement of clearance. Likely reptile mitigation strategies for the site include a fence, trap and clear operation for some of the more grassy areas and species deterrence strategies for the more rocky habitats; destructive searching is also likely to be required.

- Clearance of trees and scrub will avoid the main bird nesting season (March to August inclusive), to minimise the risk of destruction or disturbance of nests, eggs and nestlings.

- Suitable written protocols will be issued to contractors so that in the event of the discovery of bats, nesting birds, badgers or common reptiles at any time during operations, compliance with statutory obligations is ensured. These will require immediate temporary cessation of works, allowing time for consultation with NRW, and safe relocation or other mitigation as required.

- As outlined previously, there may be scope for the re-creation of similar habitats that currently occur both as the development progresses and in the post-development landscaping.

13.3.4 Planning Conditions

The proposed mitigation measures seek to implement the mitigation measures outlined above.

13.4 Hydrology and Hydrogeology

13.4.1 Hydrology and Hydrogeology Study

The study reflects the detailed requirements with respect to hydrology and hydrogeology which are asset out in the March 2013 Scoping Direction. It reflects the results of a major programme of investigation, monitoring and analysis unedertaken over the last 12 years.

The study is based upon a phased programme of work and extensive consultations and discussions with the EA, CCW and latterly NRW. A key element of the study is the conceptual model which was originally developed in support of the first voluntary ES for the Cornelly Quarry but which has now been updated in the light of subsequent further consultations and the large amount of data collected since that time.

The assessment approach has considered the source of the potential impact (dewatering associated with further working of Gaens Quarry); the pathways (the groundwater flow pathways or hydrogeological linkages identified in the conceptual model); and the receptors (the key water features identified in the water features survey). The investigations, conceptualisation, and groundwater flow model which have been undertaken and developed to assist in the prediction of groundwater level impact, have, as required by the Scoping Direction, specifically considered the possible effects of interception during quarrying of a ‘highly permeable feature’.

In presenting the results of the assessment, the study has grouped potential effects into four, as follows:

(i) Groundwater levels and flows in the Swansea Southern Carboniferous Limestone groundwater (Water Framework Directive) body (A);
(ii) Water levels in the dune sands at Kenfig SAC / Kenfig Pool and Dunes SSSI and the Merthyr Mawr SSSI (B);
(iii) Water levels and flows at other receptors (C); and
(iv) Other potential impacts, including leachate migration, ground stability and saline intrusion (D).

The effects have been considered for both the operational and restoration stages, based upon Gaens Quarry working in isolation and in combination with quarrying and restoration at Cornelly and Grove Quarries based upon the same time periods. The modelling has included a series of sensitivity runs to define the likely error margin for the respective predictions.

13.4.2 Impacts

There is the potential for small predicted hydrogeological effects but no significant hydrogeological impact on Kenfig Pool and Dunes or Merthyr Mawr SSSIs. Cefn Cribwr SAC has been discounted as there is no effective hydrological pathway.

The assessment has concluded that the predicted impacts on the local hydrology are minor. There are some effects but no significant impacts predicted for the 24 potentially vulnerable receptors.

The likelihood of encountering a significant interconnected fissure at depth has been considered in detail and is concluded to be very low. The implications of encountering such a feature (if one did exist) have been considered by means of modelling which has informed the development of a Water Management Plan for the site to tackle this residual uncertainty.

13.4.3 Planning Conditions

The key planning condition requires the implementation of the Water Management Plan and the obligations which it sets out for continual monitoring, assessment and mitigation measures if required.

A number of additional and conventional planning conditions are appropriate to enshrine the fuel handling protocol to minimise the risk of ground and surface water contamination.

13.5 Noise

13.5.1 Noise Study

An assessment has been made of the baseline situation and the potential impact of the proposals. Environmental advantages and disadvantages have been identified and where appropriate, mitigation measures and/or scheme changes to offset potentially adverse environmental impacts have been identified.

Operational noise levels generated by the mobile plant associated with operations at the site have been predicted using the methodology contained in BS5228-1:2009 and have been assessed against the guidance contained in MTAN1.

Noise levels generated by heavy goods vehicle movements have been assessed using the haul route method included within BS5228-1:2009.

13.5.2 Noise Mitigation Measures

Given that the predicted noise levels at local noise-sensitive receptors due to normal quarrying operations are within the relevant limits of MTAN1 it is considered that no further specific mitigation measures are necessary.

13.6 Blast Vibration

13.6.1 Blast Vibration Study

The assessment considers the vibration levels generated by operations at the nearby vibration-sensitive receptors. In order to predict the likely vibration magnitude, measurements were made of vibration levels at a number of locations during blasting operations at the quarry.

An assessment has been made of the potential impact of the proposals. Mitigation measures and/or scheme changes to offset potentially adverse environmental impacts have been identified.

13.6.2 Blast Vibration Mitigation Measures

The opportunity is thus available via the ROMP Review application to impose updated conditions regulating blast vibration, which accord with modern standards and the advice set out in MTAN1.

The means of controlling ground vibration, air overpressure and fly-rock have many features in common. Many of these measures are required for safety reasons by the Quarries Regulations 1999 and the approved Code of Practice.

- correct blast design is essential and should include a survey of the face profile prior to design, ensuring appropriate burden to avoid over-confinement of charge which may increase vibration by a factor of two;

- the setting out and drilling of shot holes should be as accurate as possible and the drilled holes should be surveyed for deviation along their lengths and, if necessary, the blast design adjusted;

- correct charging is obviously vital, and if free poured bulk explosive is used, its rise during loading should be checked. This is especially important in fragmented ground to avoid accidental over charging;

- correct stemming will help control air overpressure and fly-rock and will also aid the control of ground vibration. Controlling the length of the stemming column is also important; too short and premature ejection occurs, too long and there can be excessive confinement and poor fragmentation. The length of the stemming column will depend on the diameter of the hole and the type of material being used; and

- monitoring of blasting and re-optimising the blast design in light of the results, changing conditions and experience should be carried out as standard.

13.6.3 Planning Conditions.

Planning conditions are proposed that reflect the mitigation measures proposed and in accordance with MTAN1.

13.7 Air Quality

13.7.1 Air Quality Study

The scope of the assessment examines the current sources of dust emissions from the site and their impact of the continuation of quarrying on local receptors. Potential impacts at sensitive receptors in terms of exposure to dust emissions are assessed and appropriate measures are recommended where required.

The study considers a number of elements of potential dust creation. The extraction of limestone is on-going and therefore the magnitude of dust generation are not considered to materially alter or increase, provided production rate does not change. Dust generation could actually reduce as the depth of working increases, due to greater protection from the wind and increased vertical distance to receptors.

In terms of blasting, material is fragmented by blasting involving the drilling of a series of holes and filling with explosives. Overall there is considered to be a moderate potential of dust generation due to the intermittent nature of drill rig use. Blasting is currently undertaken onsite and as the extraction rate is not proposed to change the source of dust is considered to remain unchanged. However as noted above dust generation could reduce as the depth of working increases, due to greater protection from the wind.

Excavated rock from the quarry face is transported by dump truck to a mobile crusher. Operation of the plant is controlled through an Environmental Permit, Permit Number 019/03 issued by Bridgend CBC. The overall emissions from the plant are considered to be moderate. The processing operations are not considered to change and therefore the magnitude of emissions are not considered to increase above the baseline. The movement of the location of the plant within the base of the mineral void will reduce the potential for dust movement across the site boundary due to the physical barrier.

Soil and overburden removal will be undertaken to the south east of the quarry, further away from receptors within South Cornelly. Typically the potential for dust emissions from soil and overburden removal is significant13 but temporary and would vary considerably from day to day, depending on the level of activity, the specific operation, the location of the activity and the prevailing meteorological conditions.

Raw material and product will be transported within the quarry. The majority of transport will be undertaken using dump trucks and loading shovel on unpaved haul roads made of compacted material. The overall potential dust generation from internal vehicle movements is considered to be high. The number of internal vehicle movements is not expected to increase and therefore dust emissions are considered to remain the same.

Restoration of the site would involve allowing the excavation to fill with water to form a water feature, with progressive restoration of the upper quarry faces. This gradual restoration would restrict the amount of dust available to become airborne during soil moving. The potential for dust emissions from soil handling is significant but temporary and would vary considerably from day to day, depending on the level of activity, the specific operation, the location of the activity and the prevailing meteorological conditions.

13.7.2 Air Quality Mitigation Measures

A review of onsite mitigation measures has been undertaken with respect to current permitting requirements within Permit number 19/03. Mitigation measures are defined on the basis of industry good practice guidance. A review of onsite mitigation measures has been undertaken with respect to current onsite practice. The historical planning permissions for quarrying at Gaens, which form the subject of the ROMP Review, do not include detailed conditions relating to dust controls. The purpose of the ROMP Review is to update the planning conditions to reflect modern controls, and this study aims to assist that process by identifying dust generating activities and the current approach to planning conditions.

Additional mitigation measures employed onsite in accordance with the sites permit are summarised within Table 10-16 and are considered to be effective. The dust source closest to South Cornelly (where complaints have been received) is the access road and internal haul road, which are considered to be the greatest source of dust. Rigorous implementation of mitigation measures for the haul roads is considered to be highly effective at reducing emissions.

13.7.3 Planning Conditions

Detailed dust control conditions are not deemed to be necessary given the separate existing controls which are in place via the Permit. However, opportunities are available to include a general dust control protocol (a Dust Action Management Plan or similar) as a condition which draws upon the key elements of dust mitigation, but in a way which does not duplicate the PPC Permit controls and requirements.

This is reflected in the schedule of updated planning conditions which accompanies the Review application.

13.8 Traffic

13.8.1 Traffic Study

The traffic study has reviewed the nature and layout of the existing site access and local highway network.

The impact on the local highway network of the proposed development at Gaens Quarry as part of the ROMP process has considered the extant planning permission and the implications of the future operations proposed.

The historic and future activities have been identified to result in an average of 61 HGV movements on the local road network per day.

The proposed hours of operation, method of transport and types of vehicle used also accord with the extant planning permission; as does the proposed access arrangement, which will continue to use the existing connection to Porthcawl Road with traffic distributing primarily to the north along the A4229 to/from M4 Junction 37.

13.8.2 Impact Study

The existing access routes and junction have been reviewed and were found to retain significant levels of reserve capacity with the existing traffic demands and also with additional vehicles associated with Grove Quarry added to the baseline traffic flows.

It was found that the additional traffic associated with potential activities at Grove Quarry fall within existing day to day variations on the local highway network.

The safety performance of the site accesses and local highway network, which continue to accommodate daily HGV movements, has been reviewed using collision records obtained from the Council. The records confirm that there have been no recorded accidents at the access and no recorded accidents involving HGVs on the neighbouring highway network.

13.8.3 Traffic Mitigation Measures

The site incorporates satisfactory access arrangements and utilises a road network with a good standard of design, significant reserve capacity and an excellent safety record in terms of HGV traffic.

The site has surfaced haul roads along which HGVs must travel before joining the public highway to minimise the potential for detritus to be transferred to the external routes in the area. Separate provision is made to minimise dust etc, as discussed in Chapter 11.0 of the ES.

The ongoing activities at Gaens Quarry are not anticipated to result in any increases in traffic flows compared to recent averages.

No specific mitigation measures are thus deemed to be necessary, other than periodic control of vegetation to maintain visibility splays and also maintenance of the access surface.

13.8.4 Planning Conditions

The existing planning permission has been implemented without resulting in unacceptable highway and transport impacts. Given that there are no highway-related conditions imposed on the existing planning permission, and that proposed development will not increase HGV activity on the road network when compared with the existing baseline scenario, no planning conditions are considered to be necessary or are recommended.

.

14.0 PLANNING POLICY

14.1 Introduction

The review of relevant planning policy is not an express requirement of the Town and County Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999 Schedule 4 (as amended), but the exercise acts as a useful checklist in terms of the environmental topics considered in the EIA, and allows the conclusions reached by the EIA / ES to be assessed against planning policy objectives and requirements.

Section 38(6) of the Planning and Compulsory Purchase Act 2004 introduces a presumption in favour of granting planning permissions for proposals which are in accordance with policies in the development plan. However it is important to note the distinction between the circumstances of a planning application, where the principle of a development needs to be assessed against policies in the development plan, and those associated with a ROMP application, where the principle of the mineral development is already established by virtue of the extant planning permissions for quarrying which exist. The relevance of the development plan in these circumstances is more geared towards providing guidance and advice regarding environmental controls and operational practices which should be enshrined within up to date planning conditions.

It should be noted that the Welsh Government Scoping Opinion (dated 4th March 2013 and included at Appendix One) does not specifically request a review of policies.

The following documents have been considered on the policy review:

- Planning Policy Wales (Edition 6) : February 2014
- Minerals Planning Policy Wales: December 2000
- Minerals Technical Advice Note 1: Aggregates March 2004 (MTAN1)
- Bridgend Local Development Plan

14.2 National Planning Policy

14.2.1 Planning Policy Wales : February 2014

Planning Policy Wales (Edition 6) contains current land use planning policy for Wales. It provides the policy framework for the effective preparation of local planning authorities' development plans.

There are no specific minerals policies within PPW, Welsh Government's land use planning policies for minerals development are contained in a separate document Minerals Planning Policy Wales. This sets out policy in relation to short and long term future use and the safeguarding of mineral deposits. This is considered below.

Section 3.6 of Planning Policy Wales focuses on planning conditions. Paragraph 3.6.2 states conditions should only be imposed where they are:

- necessary;
- relevant to planning;
- relevant to development to be permitted
- enforceable
- precise; and
- reasonable in all other respects.

The proposed and updated set of new planning condition to accompany this ROMP submission will comply with all of the above.

14.2.2 Minerals Planning Policy Wales: December 2000

The Welsh Government's primary land use policy guidance in relation to mineral extraction and related development is set out within Minerals Planning Policy Wales (MPPW), (December, 2000).

The key objectives of MPPW are defined as seeking to provide mineral resources to meet society's needs; to protect areas of important natural and built heritage resources; to limit the environmental impact of extraction; and to achieve a high standard of restoration and beneficial after use. To this end, paragraph 67 states '*It is essential to the economic health of the country that the construction industry is provided with an adequate supply of the minerals it needs*.' In addition to the above, paragraph 34 sets out the following issues which must be considered when assessing the impact of mineral development on the environment and amenity of residents:

- Access and traffic generation,
- Noise,
- The control of dust, smoke and fumes,
- Blasting controls, land drainage and impact on groundwater resources
- Visual intrusion,
- Impact on sites of nature conservation, historic and cultural importance,
- Restoration, aftercare and after-use.

The EIA undertaken pursuant to the ROMP submission has considered each of these issues as required.

14.2.3 Minerals Technical Advice Note 1: Aggregates March 2004 (MTAN1)

MTAN1 sets out detailed advice on the mechanisms for delivering the policies of MPPW. Of particular relevance is 'Section C', which defines the objective 'to reduce the impact of aggregates production', and which outlines a number of measures of control to fulfil that objective, including control of dust, blast vibration, noise, visual impact, environmental audits, and community liaison.

MTAN1 includes specific advice on the means by which the impact of aggregate extraction might be reduced, the issues which should be considered in quarry restoration designs, and the nature of planning conditions which might control quarrying and restoration operations. The following are of particular relevance to Gaens Quarry:

(a) Vibration limits and controls

MTAN1 reviews the effects of vibration from blasting operations, and confirms that planning conditions should provide for acceptable days for blasting operations; acceptable times of blasting operations; maximum levels of ground vitiation at vibration sensitive properties; and approval of a scheme of vibration monitoring.

These issues have been considered as part of the blast vibration study set out in chapter 10.0 of the ES, and are reflected in the updated planning conditions prepared by the Applicant (ref Chapter 15.0 and Annex 1 to the ES).

(b) Noise

MTAN1 confirms that the effects of noise should be fully considered in formulating proposals for mineral extraction (para 85), and advises that the aggregate industry should aim to keep noise emissions at a level that reflect the highest possible environmental standards, taking all reasonable steps to achieve quieter working (para 87).

The advice has been considered as a context for the noise assessment set out in chapter 9.0, and is reflected in the proposed updated planning conditions relating to noise (ref chapter 15.0 and Annex 1).

(c) Dust

MTAN1 identifies a number operations that have the potential to cause dust emissions in the event of unsatisfactory site design and/or management. Dust emissions can result from haulage, particularly on internal un-surfaces routes, on nearby roads which are not adequately wetted and if vehicles are un-sheeted; crushing and grading operations; blasting, including drilling operations prior to blasting; surface stripping, including soils and overburden storage; and restoration operations." (para 72)

It recognises that planning conditions can control certain activities to protect against dust emissions, although many of these are controlled under the Environmental Protection Act 1990, and care should therefore be taken to avoid duplication of controls (para 76). However, it highlights a number of issues which might be controlled by planning conditions, including *the imposition of speed restrictions; sheeting of vehicles; the design of working programmes to locate dust emission sources away from sensitive developments; and the timing of soil handling and overburden stripping to suit weather conditions (para 77).*

This advice has similarly formed the context for the dust / air quality assessment and proposed updated planning conditions relating to dust controls prepared by the Applicant (ref Chapters 10.0, 15.0 and Annex 1). However, as discussed in Chapter 11.0, reliance is placed upon existing controls set out in the crushing and screening Permit which are not proposed to be duplicated.

(d) Landscape and Visual Impact

MTAN1 advises that proposals for new aggregates extraction or extensions to existing sites should be assessed carefully to determine the potential impact on the character of the landscape. This ES has been prepared in support of a review of planning conditions, but the principle of a careful of assessment of the landscape and visual effects of the ongoing development has been a central feature of the EIA, as reflected in the updated design of the quarry development scheme (ES chapter 3.0) and the landscape mitigation measures (ES chapter 5.0); all of which have been enshrined within the proposed updated planning conditions (ref chapters 15.0 and Annex 1).

(e) Site Management

MTAN1 advocates the undertaking of environmental audits of quarries to assess the performance of the operation against set environmental objectives (para 95).

The site management controls are re-enforced by the planning conditions (which will be updated as part of this Review) and also by the Pollution Prevention and Control Permit (PPCP) which will include conditions which limit emissions and control techniques to protect air quality. The site will also subject to regular inspection by BCBC and the NRW to ensure compliance with permit conditions.

(f) Restoration

MTAN1 places considerable emphasis on the need to achieve high standards of restoration and aftercare, and to provide for a beneficial after use. This is to be secured by careful attention to restoration design, and specific advice is provided on the key topics to be considered when drawing up reclamation conditions (ref para 111, Box 2).

MTAN1 also emphasises the need for aftercare conditions to be imposed to ensure the successful implementation of the restoration scheme, where such conditions can either specify the steps to be taken via the planning condition, or require an aftercare scheme to be submitted to the minerals planning authority for approval.

MTAN1 thus provides a useful checklist of issues to be considered as part of the objective to reduce the impact of aggregate extraction. Each environmental issue has been addressed in this ES, and the recommended criterion levels set out in MTAN1, together with the wider advice relating to planning conditions, is fully reflected in the schedule of conditions now proposed by the Applicant (ref accompanying application statement).

14.3 Bridgend Development Plan

14.3.1 Bridgend Unitary Development Plan (UDP) 2005

A noted in section 15.1, the UDPhas been replaced by the Bridgend LDP (September 2013) but the former UDP contains policies which provide a helpful context to the issues which should be included as planning conditions. Policies M2 of the UDP provides general criteria and advise regarding measures which should be taken to reduce damage or disturbance to the environment to acceptable levels. It lists a series of topics relating to ground and surface water, landscape, nature conservation, agricultural interests, sites of archaeological importance and stability of adjoining land which should be addressed as part of mineral development schemes. Specific attention is afforded to the need for measures to reduce damage or disturbance to neighbouring land uses to acceptable levels in terms of the effects of noise, dust and vibration and the impact of traffic generated by the site. Each of these issues has been considered in detail in the ES and mitigation measures capable of being translated into planning conditions have been proposed where appropriate.

Similar themes are set out in policy M10 which directly refers to 'reviewing' mineral permissions, and the planning conditions which it may be appropriate to impose. The suggested conditions and response are set out in table 15.1 below.

Table 14-1 Policy M10

Policy M10 Topic	Response
1. Vary the duration of the permission.	Included within the proposed updated schedule of conditions where the duration reflects the reserves and anticipated timescale of extraction.
2. Regulate hours of working	Detailed hours of working controls are proposed for the respective operations undertaken.
3. Measures to regulate traffic	No specific additional traffic measures are deemed to be required.

4. Mitigate noise levels to acceptable limits	The scheme has been assessed against the noise criteria set out in MTAN1, and conditions are proposed to ensure that the development continues in accordance with the MTAN1 criteria
5. Monitor blasting operations, control to specified times, and limit the effects of vibration.	Planning conditions proposed consistent with the advice in MTAN1. A
6. Minimise the impact of dust.	Dust control protocol proposed as a condition, with further reliance placed on controls via the PPC Permit
7. Monitor impact on groundwater and make provision for the protection of groundwater and surface water features.	Extensive monitoring undertaken over a period of 12 tears. Ongoing monitoring and protection of water features proposed via Water Management Plan condition.
8. Undertake archaeological assessment and record and / or protect identified features.	Assessment undertaken. No archaeological features present, and no conditions required..
9. Include landscape works or other screening operations to reduce visual effects.	Measures proposed and enshrined in updated planning conditions.
10. Provide for restoration and aftercare.	Restoration strategy prepared and referred to in schedule of planning conditions.
11. Evaluate nature conservation value and include measures for the protection of habitats or species, and mitigation measures as appropriate.	Detailed study undertaken and recommendations enshrined in updated planning conditions.

Each of the items listed in Policy M10 have thus, where relevant, been fully addressed via the EIA and updated schedule of conditions,

14.4 Local Policies: Bridgend Local Development Plan

Section 4.3 of the LDP (adpoted 2013) refers to mineral policies. Whilst the policies are not directly related to ROMP Reviews, the sentiment to minimise effects to acceptable limits is reflected in the environmental studies and the recommendations which have been made for mitigation measures, which are themselves founded on acceptable limits (particularly in relation to noise and blast vibration).

Strategic policy SP6 is shown below:

Strategic Policy SP6 - Minerals

A contribution to the national, regional and local demand for a continuous supply of minerals, in a sustainable manner, will be achieved by:

1) Maintaining a minimum 10 year supply of aggregates throughout the plan period;

2) Safeguarding identified areas of high quality finite resources of coal, sand and gravel, limestone and sandstone;

3) Promoting the efficient usage of aggregates, promoting the use of commercial and demolition waste and secondary aggregates, and maximising the use of these alternative materials before the use of virgin aggregate;

4) Ensuring that mineral development will not negatively impact on amenity and the environment;

5) Mitigate against the conflict between sensitive land uses, and mineral operations by defining buffer and exclusion zones around mineral sites and relevant settlement boundaries respectively.

The ROMP Review will ensure that maintaining the minimum 10 year supply is continuously achievable, it will continue to promote the efficient use of aggregates, secondary aggregates and ensure mineral development will not negatively impact on amenity and the environment through an updated set of planning conditions prepared by the applicant.

Mineral Development Policy ENV11 is shown below:

Mineral Development Policy ENV11

All mineral related developments, including coalbed methane, will be permitted only where all of the following criteria are satisfied:

1) Measures can be taken to reduce, and where possible avoid, damage or disturbance to the environment to acceptable levels with specific reference to:

a) Pollution or disturbance to ground or surface water supply or drainage;
b) The impact on the landscape of the area;
c) The effect on nature conservation and wildlife interests of the site and adjoining land;
d) The effect on agricultural interests particularly on high quality agricultural land;
e) The effect on sites of archaeological importance;
f) The impact on the stability of adjoining land; and
g) The potential for mine gas emissions.

2) Measures can be taken to reduce damage or disturbance to neighbouring land uses to acceptable levels including:

a) The effects of excessive noise, dust or vibration arising from the methods of working set out in a health impact assessment; and

b) The impact of traffic generated to and from the site.

3) Proposals for the duration and phasing of operations, restoration, beneficial after-use and aftercare are acceptable and priority should be given to a nature conservation end use.

Policy ENV11 confirms that development proposals will not be permitted where they would cause or result in unacceptable harm to local amenity because of , inter alia, air pollution, noise pollution, water pollution or any other risk to the environment. Again this policy is geared towards the consideration of planning applications for new developments, but the identified issues have been fully considered as part of the EIA, and measures are available, which can be imposed as planning conditions (or are regulated by other regimes) to ensure that the ongoing development will not give rise to “unacceptable harm” to local amenity.

14.5 Planning Policy Conclusions

The summary review of national and local planning policies has assisted in highlighting the advice and policy issues which should be reflected in planning conditions controlling ongoing activities at Gaens Quarry. The advice and policies represent up to date criteria and best environmental management practice relating to, inter alia, noise, blast vibration, and dust control, and more general advice relating to landscape.

The policies have provided a further checklist of environmental issues relevant to the assessment, and the topics and issues which are likely to require control via planning conditions.

The Applicants have thus sought to fully reflect this advice in the updated schedule of conditions they have prepared, which is produced as Annex 1 to the ES.

15.0 CONCLUSIONS

The Environment Act 1995 introduced a process of Periodic Reviews of mineral permissions at 15 year intervals. This is designed to ensure that planning conditions do not become outdated with the passage of time, and to more generally ensure that conditions reflect up to date standards and requirements. This process of a 'Review of Old Mining Permissions' is commonly referred to by the term 'ROMP Review'.

A ROMP Review application for Gaens Quarry was submitted to Bridgend County Borough Council (BCBC) in June 1997, accompanied by a statement in support of the application, and a scheduled of proposed updated planning conditions.

By letter dated 29th July 1998, the Gaens ROMP Review application was 'called-in' by the Welsh Office (now Welsh Government (WG) for their determination.

Discussions on the content of the Gaens ES continued, and a substantial measure of agreement emerged regarding the technical issues. However, prior to the final resolution of the outstanding issues, the Welsh Government introduced new regulations relating to ROMP applications which, for varying reasons, had become "stalled".

The ES has been prepared pursuant to the requirements of those regulations (the Town and Country Planning (Environmental Impact Assessment) (Mineral Permissions and Amendment) (Wales) Regulations 2009), which came into force on 8th January 2010.

The Regulations introduce a requirement for EIAs to be undertaken in relation to 'stalled reviews', where such EIAs and ES's would update and replace any voluntary ES's which had been submitted. The Regulations also introduce a formal timetable for the completion and submission of the formal ES's which is designed to bring closure to the 'stalled' process.

The 2009 Regulations require the Welsh Government, in cases which have been called in by the Welsh Ministers, to issue a "Scoping Direction" setting out the issues which should be addressed as part of an EIA, and confirming the timescale in which the EIA should be undertaking and a draft ES submitted.

A formal Scoping Direction was issued on 4th March 2013. The Applicants have ensured that each issue is fully addressed as part of the EIA and this ES and, for ease of reference, a detailed table has been prepared which identifies the issues raised in the Scoping Direction, the way in which the issues have been addressed as part of the EIA, and the reference within the ES (reference table 1.2).

The Gaens Quarry ROMP Review ES considers the environmental effects of the continued extraction from the remaining void of the Quarry to a maximum depth of -20m. In addition, consideration is given to the restoration of the site in combination with the lapsed Interim Development Order permission to the north-west of the extraction area.

In addition, the ES considers the cumulative impacts of the proposed extraction and restoration scheme at Gaens Quarry with the nearby Cornelly and Grove Quarries.

The primary purpose of the ES is to assist in identifying environmental effects, and to use that information to devise measures to minimise the environmental effects through an updated design of the quarry development scheme and / or via specific mitigation measures which can be translated into planning conditions which regulate ongoing quarrying in a way which is reflective of the EIA.

The purpose of the ROMP Review is to formulate a schedule of updated planning conditions which reflect modern standards and controls, and which provide (i) detailed controls over on-going operations for the 15 year Review period; and (ii) a context for subsequent Periodic Reviews by confirming the longer term intentions for the development of the Quarry, and the final restoration strategy.

The updated conditions proposed by the Applicant are considered to represent a positive and constructive approach to devising an environmental sensitive operation and to regulating the development by modern, up to date planning controls. In those termsthe exercise associated with the EIA has been of positive value in preparing specific conditions which reflect the conclusions and recommendations of the EIA.

TERM	DEFINITION
ROMP	Review of Old Mining Permissions
ROMP area	Area which is the subject of the ROMP application
Applicants	The Applicant is TS Rees Limited, a privately owned and independent company.
Cornelly Group of Quarries	This comprises Gaens Quarry, Cornelly Quarry and Grove Quarry
IDO	Interim Development Order, which granted planning permissions for developments prior to the introduction of the1947 Town and Country Planning Act.
Regulators	Natural Resources Wales, formerly Environemnt Agency Wales (EAW) and Countryside Council for Wales (CCW)
Aftercare management	Management designed to ensure the success of restoration works.
Mineral Planning Authority	The Authority responsible for planning control of mineral working sites, currently Bridgend County Borough Council
MPPW	Minerals Planning Policy Wales December 2000
MTAN1	Minerals Technical Advice Note 1 : Aggregates March 2004
Bridgend LDP	Bridgend County Borough Council Local Develepment Plan, adopted September 2013
Operational Stage	Works during the quarrying and processing operations
Restoration Stage	Works followng the completion of quarrying
Decommissioning stage	Works associated with final restoration including removal of residual plant and groundwater recovery
Cornelly quarry development	This comprises the extraction of limestone from the quarry and related oparations of quarry waste tipping.
LANDSCAPE AND VISUAL IMPACT ASSESSMENT	
Analysis	The process of breaking the landscape down into its component parts to understand how it is made up.
Assessment	An umbrella term for description, analysis and evaluation.
Baseline	A term to describe environmental conditions prior to development.
Character	A distinct pattern or combination of elements that occurs consistently in particular landscape.
Character Area	A geographic area with a consistent character.
Criteria	Factors that determine levels of sensitivity and magnitude.
Designated Landscape	Areas of landscape identified as being of importance at international, national or local levels, either defined by statute or identified in development plans or other documents.
Direct effect	An effect that is directly attributable to the proposed development.
Enhancement	Landscape improvement through restoration, reconstruction or creation.
Feature	A prominent, eye-catching landscape element (eg wooded hilltop, church spire).
Indirect Impact	Impacts which occur as a secondary or tertiary effect of a development, as a result of changes in a chain of environmental parameters.
Landform	Combination of slope and elevation producing the shape and form of the land surface.
Landscape	An area, as perceived by people, the character of which is the result of the action and interaction of natural and/or human factors.
Landscape Character	A distinct, recognisable and consistent pattern of elements in the landscape that makes one landscape different from another, rather than better or worse.
Landscape Character Assessment	The process of identifying and describing variation in the character of the landscape, and using this information to assist in managing change in

	the landscape. It seeks to identify and explain the unique combination of elements and features that make landscapes distinctive.
Landscape Effects	Change in the fabric, character and quality of the landscape as a result of development.
Landscape Quality (Condition)	A measure of the physical state of the landscape. It may include the extent to which typical character is represented in individual areas, the intactness of the landscape and the condition of individual elements.
Landscape Receptors	Defined aspects of the landscape resource that have the potential to be affected by a proposal.
Landscape Value	The relative value that is attached to different landscapes by society. A landscape may be valued by different stakeholders for a whole variety of reasons.
Magnitude (of effect)	A term that combines judgements about the size and scale of the effect, the extent of the area over which it occurs, whether it is reversible or irreversible and whether it is short or long term in duration.
Quality	Term used to indicate the value of a landscape, based on its character, condition and aesthetic appeal.
Sensitive Receptor	Physical or natural landscape resource, special interest or viewer group that will experience impact.
Sensitivity	Vulnerability of sensitive receptor to impact.
Severe(ity)	Term used to define a general level of impact significance.
Significance	A function of sensitivity and magnitude.
Significant	Term used to define a specific level of impact significance.
SLA	Special Landsacpe Area defined in the Bridgend Local Development Plan
Slight	Term used to define a specific level of impact significance.
Source	Project characteristic giving rise to impact.
Study Zone	Map showing the location of sensitive receptors within defined limits of the development.
Study Area	In this case a study area extending 20km from the Gaens Quarry site has been defined for the purposes of identifying landscape designations.
Susceptibility	The ability of a defined landscape or visual receptor to accommodate the specific proposed development without undue negative consequences.
Technique	Specific tool for assessment eg. visibility mapping.
Tranquillity	A state of calm and quietude associated with peace, considered to be a significant asset of landscape.
Visual Amenity	Term indicating popularity of a particular area or view.
Visual Receptors	Individuals and/or defined groups of people who have the potential to be affected by a proposal.
Visual Impact	Change in the appearance of the landscape as a result of development.
Visual Intrusion	Degree to which a development intrudes upon the human field of view.
Visualisation	Computer simulation, photomontage or other tool to illustrate the appearance of new development.
Zone of Visual Influence/ Visual Envelope	Extent of potential visibility to or from the development.
ECOLOGY	
Ancient Woodland	Woodland which has existed since at least 1600 AD, and possibly much longer. Two broad types of ancient woodland can be identified; as below.
Ancient Semi-Natural Woodland (ASNW)	Woodland that is composed of native tree and shrub species which have not obviously been planted.
Plantation on Ancient Woodland Sites (PAWS)	Woodland that which has been continuously wooded since 1600 AD but where the former tree cover has been replaced with planted trees (often conifers).
Annex I habitat type(s)	A natural habitat listed in Annex I of the EC Habitats Directive.
Biodiversity	"The variability among living organisms from all sources including, inter

	alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (UN Convention on Biological Diversity 1992).
Birds of Conservation Concern	Assessment of the conservation status of UK birds. A total of 247 species have been assessed, and each placed onto one of three lists – red, amber or green. Red list species are those that are Globally Threatened and whose populations or range have declined rapidly in recent years. Amber list species are those with an unfavourable conservation status in Europe; those whose population or range has declined moderately in recent years; are rare breeders and those with internationally important or localised populations.
Calcareous	Habitats derived from limestone or chalk substrates.
CCW	Countryside Council for Wales – previously the statutory advisor to the Welsh Assembly Government on wildlife, landscape and access (now NRW).
Ecosystem	An ecosystem is a natural unit consisting of all plants, animals and micro-organisms (biotic factors) in an area functioning together with all of the nonliving physical (abiotic) factors of the environment.
EA	Environment Agency (now NRW)
Flora and Fauna	The animal or plant life of a particular area or time.
Flushes and Seepages	Wetland features often of a localised occurrence where the ground is marshy due to inputs from groundwater.
Habitats Directive	In 1992 the European Community adopted Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora (EC Habitats Directive). The Directive requires Member States to introduce a range of measures including the protection of habitats and species listed in the Annexes.
Invasive species	Plants, animals and microbes not native to a region which, when introduced either accidentally or intentionally, are harmful to the environment by outcompeting native species for available resources, reproducing prolifically, or dominating regions and ecosystems.
Local Nature Reserves (LNRs)	Declared by local authorities, in consultation with Natural England, under Section 21 of the National Parks and Access to the Countryside Act 1949. They are sites with wildlife or geological features that are of special interest locally, which give people opportunities to study, enjoy and have contact with nature.
Natura 2000	Network of Special Areas of Conservation and Special Protection Areas.
National Nature Reserve (NNR)	Statutory designation under the National Parks and Access to the Countryside Act 1949 and the Wildlife and Countryside Act 1981. NNRs contain examples of some of the most important natural and semi-natural terrestrial and coastal ecosystems in Great Britain. They are managed to conserve their habitats or to provide special opportunities for scientific study of the habitats communities and species represented within them. This designation is for land areas; the equivalent marine designation is Marine Nature Reserve.
Phase 1 Habitat Survey	A basic audit of site habitats in accordance with a defined methodology and mapping convention.
Phase 2 Habitat Survey	A more detailed survey of habitats to determine their community type in accordance with the National Vegetation Classification (NVC).
SEWBREC	South East Wales Biodiversity Records Centre.
SINC	Site of Importance for Nature Conservation. A non-statutory designation usually made by Local Authorities of sites of up to county level value.
Site of Special Scientific Interest (SSSI)	Nationally important sites forming a network of the best and most representative examples of our wildlife and geodiversity features. Selected and designated by CCW and afforded protection under the Wildlife and Countryside Act 1981 (as amended).

Special Areas of Conservation (SACs)	Designated under European Communities Directive 92/43/EEC known as the 'Habitats Directive'. This requires the conservation of important, rare or threatened habitats and species across Europe.
UK Biodiversity Action Plan (UK BAP)	The UK Biodiversity Action Plan, published in 1994, was the UK government's response to signing the Convention on Biological Diversity (CBD) at the 1992 Rio Earth Summit. It sets out a programme for the conservation of the UK's biodiversity.
The Wildlife and Countryside Act 1981	The Wildlife and Countryside Act 1981 gives protection to gives protection to native species (especially those at threat), controls the release of non-native species, enhances the protection of SSSIs and builds upon the rights of way rules in the National Parks and Access to the Countryside Act 1949. The Act is split into 4 parts covering 74 sections, it also includes 17 schedules.
HYDROLOGY / HYDROGEOLOGY	
Above Ordnance Datum (AOD)	Above Ordnance Datum: ground levels are measured relative to the mean sea level at Newlyn in Cornwall, referred to as "Ordnance Datum". Heights are reported in metres above AOD hence m AOD.
Abstraction	Removal of water from a source of supply (surface or groundwater).
Abstraction licence	The authorisation granted by the NRW to allow the removal of water.
Adsorption	The process of holding molecules of gas or liquid to the surface of particles in a thin film.
Anisotropy	Anisotropy is the property of being directionally dependent, as opposed to isotropy, which means homogeneity in all directions. It can be defined as a difference in a physical property (in this context usually hydraulic conductivity) for some material when measured along different axes.
Anthropogenic	Originating as a result of man's activities.
Anticline	A arch-shaped geological structure formed by a fold in which geological strata dip outwards.
Aquifer	A geological formation that can store and transmit groundwater in significant quantities.
Baseflow	The component of river flow that is derived from groundwater sources rather than surface run-off.
Bedding plane	A distinct surface of contact between two sedimentary rock layers.
Borehole	A hole bored into the ground for geological investigation or for the exploitation of geological deposits. An abstraction borehole is a well sunk into an aquifer from which water will be pumped.
British Geological Survey (BGS)	British organisation for mapping geology, partly funded by the Natural Environment Research Council. See www.bgs.ac.uk
Calibration	Adjustment to a numerical model to ensure its accuracy or response is acceptable: the process whereby model simulations are compared with field observations from the system being modelled, and the model being adjusted if necessary
Catchment	The area from which surface water and/or groundwater will collect and contribute to the flow of a specific river, abstraction or other specific discharge boundary. Can be prefixed by 'surface water' or 'groundwater' to indicate the specific nature of the catchment.
Cell	Generally the smallest unit within a numerical model within which water flux calculations are carried out.
Cell node	The centre of a cell at which the parameters, calculations, and results apply.
Conceptual model	A simplified representation or working description of how the real hydrogeological system is believed to behave. A quantitative conceptual model includes preliminary calculations, for example, of vertical and horizontal flows and of water balances.

Confined aquifer	An aquifer where the groundwater level as measured in a piezometer would be above the top of the aquifer. These aquifers are typically overlain by low permeability deposits.
Dewatering	A system of wells or sumps which are continuously pumped to lower the water table, providing stable, dry conditions allowing excavation to take place.
Diffuse Source Pollution	Pollution which arises as a result of many sources, from no one clear discharge point. Caused by a range of dispersed urban and rural land use activities.
Dilute and disperse	A method of managing contaminants whereby the effects of dilution within the groundwater are sufficient to reduce concentrations to acceptable levels.
Dip tube	Pipe inserted into the ground from which groundwater levels can be measured.
Discharge	The release of substances (i.e. water, sewage, etc.) into surface waters.
Discontinuity	A surface separating rock layers of differing properties or compositions
Downthrown	A description of the block of a fault which has observable downwards movement relative to the other side. The downthrow is the vertical component of the displacement of the two blocks.
Drawdown	Reduction in groundwater level relative to a previous reference groundwater level.
Effective rainfall/precipitation	Rainfall which remains following evaporation and evapotranspiration. This will either flow direct to streams (runoff) or recharge the groundwater system.
Environment Agency	Environmental regulatory authority in England established by the Environment Act 1995.
Evapotranspiration	The total loss of water as a result of transpiration from plants and the evaporation of water from soil, rock and surface water.
Fault	A rupture of lithological strata due to strain, in which displacement is observable. Reverse faults are compressional with one block moving over the other to some degree and normal faults are extensional with the blocks sliding away from each other.
Flow network model	A mathematical representation of flows in a groundwater system.
Formation	A geological layer.
Fracture	A breakage in a rock mass. Can be applied at any scale from a single crystal upwards but is generally used for large scale discontinuities. It implies breakage along a direction that is not the cleavage/fissility direction.
Gauged flow records	Records of flow in a river as conventionally measured. They reflect natural runoff from the catchment and artificial influences (abstraction, discharge, etc) that occur upstream of the measurement point.
Gauging station	A site where the flow of a river is measured
Groundwater	Water that is contained in underground rocks.
Groundwater level	The elevation which groundwater attains in a borehole at a specific location. Note that, where vertical hydraulic gradients are present, boreholes at the same location but with differing screened thicknesses may have different groundwater levels. Groundwater levels are normally considered to be equivalent to hydraulic heads although factors such as borehole construction and water density may invalidate this assumption.
Groundwater rebound	The rise in groundwater level that occurs after cessation of abstraction.
Hydraulic conductivity (K)	A constant of proportionality in Darcy's law that allows the calculation of the rate of groundwater flow from the hydraulic gradient. For a unit hydraulic gradient, the higher the hydraulic conductivity the higher the rate of groundwater flow.
Hydraulic head	Hydraulic head is a measure of potential energy represented by the groundwater at any point in an aquifer relative to a datum point. It is a

	combination of the elevation head and pressure head. Hydraulic head can be measured by the elevation of the water level in a borehole screened
Hydraulic gradient	In an aquifer this is the rate of change of groundwater level per unit distance in a given direction. Groundwater flows in the direction of the decline in hydraulic gradient.
Hydrograph	A graph showing a plot of water flow or level versus time.
Impermeable	A characteristic of a rock, soil or sediment that resists the passage of water
Karstic Aquifer	A body of soluble rock that conducts water principally via enhanced (conduit or tertiary) porosity formed by the dissolution of the rock. Karst aquifers are characterised by a network of conduits and caves..
Leachate	Liquid which is produced within or percolates through potentially contaminating material and which may contain contaminants as a result.
Licence	Formal permit allowing the holder to engage in an activity (in the context of this report, usually abstraction), subject to conditions specified in the licence itself and the legislation under which it was issued.
Lithology	The general characteristics of a rock or sedimentary formation.
Mean flow	A long term average of the daily flow.
Megalitres per day	Equal to thousand cubic metres per day.
Met Office Rainfall and Evaporation Calculation System	A generic name for Meteorological Office services involving the routine calculation of soil moisture and evaporation for Great Britain and uses a grid of 40 x 40 km squares.
Metres above ordnance datum	See 'Above Ordnance Datum'
Natural Resources Wales (NRW)	Environmental regulatory authority in Wales, incorporating the Welsh section of the Environment Agency, Forestry Commission Wales and the Countryside Council for Wales. Established in 2013.
Naturalisation	Process of converting gauged flows into natural flows by removing consumptive abstraction and discharge impacts.
Nitrogen budget	A quantification of the amount of nitrogen in various forms within a system (e.g. within soil and groundwater).
Outcrop	Where rock strata are exposed at the ground surface (often beneath soil or other superficial deposits).
Non-aquifer	An impermeable body of rock or stratum of sediment that acts as a barrier to the flow of groundwater.
Palaeokarst	An area of karstified rock which has been in filled by later sediments, preventing further karstification.
Perennial spring	A spring which flows throughout the year.
Perched aquifer	An unconfined aquifer containing groundwater which is separated from an underlying unconfined aquifer by an unsaturated zone and shallow impermeable horizon.
Permeability	The capacity of soil or porous rock to transmit water.
Photodecomposition	The process of breaking down under exposure to light.
Piezometer	A borehole designed specifically to allow the measurement of groundwater level. Other methods of measuring groundwater levels (e.g. in abstraction boreholes) are available.
Piezometric surface	The level to which groundwater would rise in a piezometer if it is free to seek equilibrium with the atmosphere.
Porosity	The ratio of the total volume of pores and interstices in a rock or soil to its total volume. Expressed either as a fraction or as a percentage.
Porous	Containing void spaces. Virtually all sedimentary rocks are porous to some extent, and the term is commonly restricted to rocks which have significant effective porosity.
Potential evapotranspiration (PE)	The maximum loss of water from the surface (leaf canopy plus soil) when there is no restriction due to lack of soil moisture.
Public water supply	Term used to describe the supply of water provided by a water company.

Pumping test	Abstraction from a borehole to determine local aquifer properties.
Q95	The flow of a river which is exceeded on average for 95% of the time.
Reach	Section of a river between two points
Recharge	Water which percolates downward from the surface into groundwater.
Recirculation	The movement of water from a discharge point back to the point that it was abstracted from.
Risk assessment	Assessment of the risks associated with normal operation and possible accidents involving a source or practice. This includes consequence assessment.
Saline intrusion	Entry of salt water into an aquifer, from the sea or estuary, due to groundwater depression normally caused by excessive groundwater abstraction.
Saturated zone	The zone in which the voids in a rock or soil are filled with water at a pressure greater than atmospheric.
Sensitivity analysis	The variation of parameter values in a numerical model to determine the sensitivity of the results to the parameter being varied.
Soakaway	An excavation in the ground into which water is directed and allowed to discharge to the surrounding soil.
Solid geology	Bedrock geology as distinct from superficial geology which is typically glacial or post-glacial.
Solution enhanced fissures (conduits)	Fissures in limestone that are enlarged by dissolution of calcium carbonate by acidic water passing through them.
Seepage	The movement of water into or out of a material. A relatively slow flow rate is often implied so that, for example, a seep from an aquifer would be a lower flow rate than a spring.
Scenario	Describing a possible sequence or outcome of future events.
Site of Special Scientific Interest (SSSI)	An area given a statutory designation by English Nature or NRW because of its nature conservation value.
Special Area of Conservation (SAC)	Protected sites designated under the EC Habitats Directive due to their conservation value, providing protection for a wide variety of animals, plants and habitats.
Specific yield	The ratio of the volume of water that will drain, by gravity, from rock or soil that was initially saturated.
Steady state	(of a numerical model) The use of parameter values that do not vary through time (e.g. long term averages) to produce a model result that also does not vary through time.
Storage coefficient	The volume of water that an aquifer releases from or takes into storage per unit surface area of aquifer per unit change in groundwater level normal to that surface.
Strata	Layers of rock, including unconsolidated materials such as sands and gravels.
Stratigraphy	The study of stratified rocks, their nature, their occurrence, their relationship to each other and their classification.
Sump	A point of low elevation to which water is directed and at which it collects. It is often removed by pumping.
Superficial deposits	Loose deposit(s) of sand, gravel, clay, etc on top of bedrock. Synonymous with 'drift', but a more modern term.
Surface water	This is a general term used to describe all water features such as rivers, streams, springs, ponds and lakes.
Surface water catchment	The area from which runoff would naturally discharge to a defined point of a river, or over a defined boundary.
Swallow hole/sinkhole/swallet	A hole in the ground, often found in limestone areas, through which a surface stream disappears underground
Syncline	A trough-like geological structure formed either by a fold in which geological strata dip inwards or faulted strata where the vertical displacements on parallel faults form a trough-like structure. Many synclines in rocks have a combination of both genetic mechanisms.

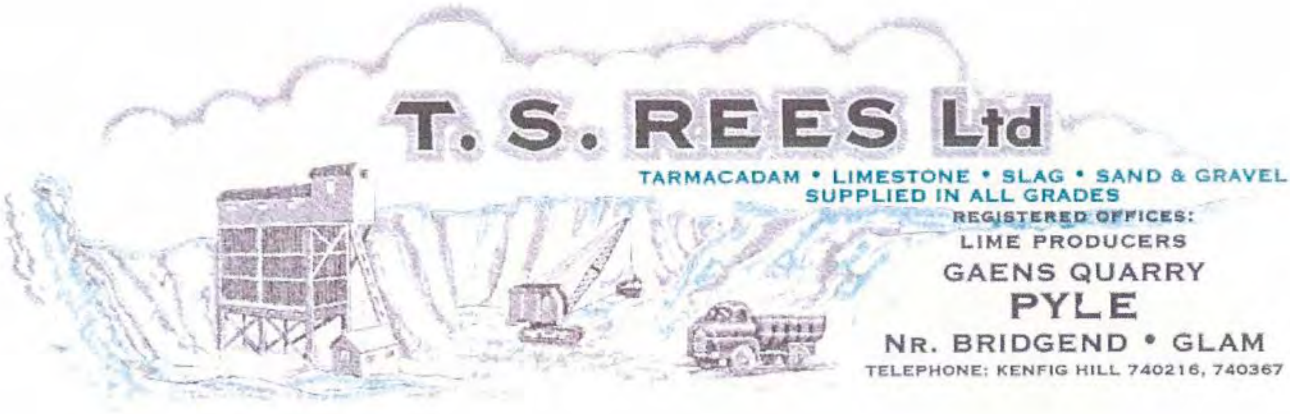
Till	Glacial deposits, dominantly unsorted and unstratified, that are generally unconsolidated, consisting of a heterogeneous mixture of particle sizes from clay to boulders.
Tracer test	A method of determining water flow paths and velocities by introduction of a “tracer” which can be monitored for at various locations downstream of the point of introduction.
Transient	(of a model) The use of parameter values that vary through time to produce a model result that also varies through time.
Transmissivity (T)	A measure of the ease at which water moves through a porous medium.
Unconfined aquifer	An aquifer whose upper boundary is the water table and not contained by an upper low permeability layer.
Unconformity	A junction between two rock masses representing a significant break in time, deposition, or structure.
Unsaturated zone	An area below the immediate surface of the ground but above the saturated zone.
Vadose	Of or relating to the unsaturated zone above the groundwater table.
Washout	The removal of sediment from filled voids through erosion by water.
Water Framework Directive	First major review of European water policy. Seeks to improve water quality in rivers and groundwater in an integrated way.
Water balance	Identification and quantification of water entering and exiting a selected system (e.g. an aquifer). Lumped water balances are those which combine various inputs and outputs for a given system or group of systems.
Water strike	The elevation at which water or a rise in water level is encountered within a borehole.
Water table	Level below which the ground is saturated with water The water table elevation may vary with recharge and pumping of boreholes.
Water table rebound	A rise in the water table following a period where it has been depressed (usually as a result of dewatering or other abstraction).
NOISE	
Decibels dB	Noise levels are measured in decibels. The decibel is the logarithmic ratio of the sound pressure to a reference pressure ($2x10^{-5}$ Pascals). The decibel scale gives a reasonable approximation to the human perception of relative loudness. In terms of human hearing, audible sounds range from the threshold of hearing (0 dB) to the threshold of pain (140 dB).
A-weighted Decibels dB(A)	The ‘A’-weighting filter emulates human hearing response for low levels of sound. The filter network is incorporated electronically into sound level meters. Sound pressure levels measured using an ‘A’-weighting filter have units of dB(A) which is a single figure value to represent the overall noise level for the entire frequency range. A change of 3 dB(A) is the smallest change in noise level that is perceptible under normal listening conditions. A change of 10 dB(A) corresponds to a doubling or halving of loudness of the sound. The background noise level in a quiet bedroom may be around 20 –30 dB(A); normal speech conversation around 60 dB(A) at 1 m; noise from a very busy road around 70-80 dB(A) at 10m; the level near a pneumatic drill around 100 dB(A).
Façade Noise Level	Façade noise measurements are those undertaken near to reflective surfaces such as walls, usually at a distance of 1m from the surface. Façade noise levels at 1m from a reflective surface are normally around 3 dB greater than those obtained under freefield conditions.
Free field Noise Level	Freefield noise measurements are those undertaken away from any reflective surfaces other than the ground.

Frequency Hz	The frequency of a noise is the number of pressure variations per second, and relates to the "pitch" of the sound. Hertz (Hz) is the unit of frequency and is the same as cycles per second. Normal, healthy human hearing can detect sounds from around 20 Hz to 20 kHz.
Octave and Third-Octave Bands	Two frequencies are said to be an octave apart if the frequency of one is twice the frequency of the other. The octave bandwidth increases as the centre frequency increases. Each bandwidth is 70% of the band centre frequency. Two frequencies are said to be a third-octave apart if the frequency of one is 1.26 times the other. The third octave bandwidth is 23% of the band centre frequency. There are recognised octave band and third octave band centre frequencies. The octave or third-octave band sound pressure level is determined from the energy of the sound which falls within the boundaries of that particular octave of third octave band.
Equivalent Continuous Sound Pressure Level LAeq,T	The 'A'-weighted equivalent continuous sound pressure level $L_{Aeq,T}$, is a notional steady level which has the same acoustic energy as the actual fluctuating noise over the same time period T. The $L_{Aeq,T}$ unit is dominated by higher noise levels, for example, the $L_{Aeq,T}$ average of two equal time periods at , for example, 70 dB(A) and 50 dB(A) is not 60 dB(A) but 67 dB(A). The $L_{Aeq,T}$ unit was commended by the Noise Advisory Council and is the chosen unit of BS5228 for Construction and Open site noise and BS 7445 for the Description and Measurement of Environmental noise.
Maximum Sound Pressure Level LAMax	The L_{Amax} value describes the overall maximum 'A'-weighted sound pressure level over the measurement interval. Maximum levels are measured with either a fast or slow time weighted, denoted as $L_{Amax,f}$ or $L_{Amax,s}$ respectively.
Sound Exposure Level LAE or SEL	The sound exposure level is a notional level which contains the same acoustic energy in 1 second as a varying 'A'-weighted noise level over a given period of time. It is normally used to quantify short duration noise events such as aircraft flyover or train passes.
Statistical Parameters LN	In order to cover the time variability aspects, noise can be analysed into various statistical parameters, i.e. the sound level which is exceeded for N% of the time. The most commonly used are the $L_{A01,T}$, $L_{A10,T}$ and the $L_{A90,T}$. **$L_{A01,T}$** is the 'A'-weighted level exceeded for 1% of the time interval T and is often used to gives an indication of the upper maximum level of a fluctuating noise signal. **$L_{A10,T}$** is the 'A'-weighted level exceeded for 10% of the time interval T and is often used to describe road traffic noise. It gives an indication of the upper level of a fluctuating noise signal. For high volumes of continuous traffic, the $L_{A10,T}$ unit is typically 2–3 dB(A) above the $L_{Aeq,T}$ value over the same period. **$L_{A90,T}$** is the 'A'-weighted level exceeded for 90% of the time interval T, and is often used to describe the underlying background noise level. It is defined in British Standard 4142 as the background noise unit and is used for establishing the reference against which industrial noises are assessed.
BLAST VIBRATION	

Displacement	The distance that a particle moves before returning to its original position, measured in millimetres (mm).
Velocity	The rate at which particle displacement changes, measured in millimetres per second (mms-1).
Acceleration	The rate at which the particle velocity changes, measured in millimetres per second squared (mms-2) or in terms of the acceleration due to the earth's gravity (g)
Frequency	The number of oscillations per second that a particle undergoes measured in Hertz (Hz
PV	Particle Velocity in mms-1
π	pi, a mathematical constant that is the ratio of any circle's circumference to its diameter
F	frequency
A	amplitude
Cosmetic or threshold	the formation of hairline cracks or the growth of existing cracks in plaster, drywall surfaces or mortar joints
Minor	the formation of large cracks or loosening and falling of plaster on drywall surfaces, or cracks through bricks/concrete blocks.
Major or structural	damage to structural elements of a building
SD	scaled Distance in mkg-½
W	maximum Instantaneous Charge (MIC) in kg, i.e. maximum weight of explosive per delay interval in kg
a	a dimensionless site factor is the peak particle velocity intercept at unity scaled distance
b	a dimensionless site factor and is the slope of the regression line
D	separation Distance (Blast to Receiver) in metres
PPV	maximum Peak Particle in mms-
AIR QUALITY	
AQMA	Air Quality Management Area
AQS	Air Quality Strategy
HGV	Heavy Goods Vehicle
AADT	Annual Average Daily Traffic Flow
LAQM	Local Air Quality Management
PM_{10}	Airborne particulate matter with an aerodynamic diameter of 10µm or less
$\mu g/m^3$	Units of concentration, micograms in a cubic meter of air
NO^2	Nitrogen Dioxide
AURN	Automatic Urban and Rural Network
DMRB	Design Manual for Roads and Bridges, produced by the Highway Agency

Appendix D

Approved Water Management Plan



VOLUME 2C

APPENDIX 7.5 – GAENS QUARRY WATER MANAGEMENT PLAN

ENVIRONMENT ACT ROMP REVIEW:

GAENS QUARRY SOUTH CORNELLY, BRIDGEND

SLR

June 2014

Appendix 7/5

Gaens Quarry Management Plan

Water Management Plan for Gaens Quarry

Report reference: 6227 WMP Gaens Quarry v5.0, February 2014
Report status: Revised WMP for 2014 ES

CONTENTS

FIGURES

APPENDICES

PREFACE

Gaens Quarry is currently the subject of an Environment Act 'ROMP Review' which will update the planning conditions controlling future operations at the Quarry. The Applicant, T.S Rees Limited, has proposed a series of updated planning conditions as required by the Review, including a commitment to carry out the development in accordance with a 'Water Management Plan' (WMP).

This WMP has been revised in light of the Environmental Statement for Gaens Quarry (SLR, 2014) prepared in 2014 in response to the Scoping Direction issued by the Welsh Government on 3 March 2013 (ref A-PAA-25-08-004 –). The Scoping Direction included a requirement to prepare a revised WMP:

> *The ES should include a refinement of the water management plan, which should include a description of water management measures at the quarries, linked to the proposed works, quarry development, quarry decommissioning and reinstatement and set out the monitoring programme, a description of any necessary remedial strategy and any actions the operator would take to prevent and/or reverse any impacts. This should facilitate the improved understanding of the regional and local water regime and the nature of any uncertainty which might remain.*

It is anticipated that this refined WMP will be cross referenced in a final version of a schedule of planning conditions which will be imposed by the determining Authority (Welsh Government).

1 DEFINITIONS

Appropriate Calculations are defined in Section 6.6

Assessment Criteria are 'standards' against which data can be compared in order to assess whether there has been a Deviation from the behaviour at that site relative to the behaviour that would be anticipated under 'natural'[1] conditions.

Climate Based Assessment Criterion is defined in Section 6.3.1 and Climate Based Assessment Criteria will be interpreted accordingly

Contingency Measures are defined in Section 8

Deviation from a Trigger Level Assessment Criterion is defined in Section 6.2.1.

Deviation from a Climate Based Assessment Criterion is defined in Section 6.3.1.

Mitigation means the application of one or more of the measures described in Section 7.1

Pathway is defined in Section 4.1

The **Quarry Operator** means the Company that operates Gaens Quarry

Receptor is defined in Section 4.1

The **Regulator** means the public body that is responsible for ensuring that the activities that the Quarry Operator is required to carry out under this Water Management Plan (WMP) are carried out. On formal adoption of the WMP this will be Bridgend County Borough Council

Sensitivity Criteria are defined in Section 6.3.2

Significant Deviation from a Trigger Level Assessment Criterion is defined in Section 6.2.2

Significant Deviation from a Climate Based Assessment Criterion is defined in Section 6.3.2

Source is defined in Section 4.1

Trigger Levels are defined in Section 6.2.1

[1] There is a wide range of possible mechanisms that can cause variation from 'natural' conditions. Where these cannot be easily distinguished using the available data, Appropriate Calculations (Section 6.6) may be needed to estimate the relative significance of different potential causes.

2 INTRODUCTION

2.1 Background

Gaens Quarry (the "Quarry") is located to the east of South Cornelly village, between the towns of Pyle and Porthcawl. The quarry works Carboniferous Limestone which is used in supply construction contract within South Wales. The total area covered by existing consents for mineral extraction at the Quarry is approximately 13 ha.

The main quarry floor is currently at around 30 to 35 mAOD. There are two main sumps which are used to work lower benches: the eastern sump is excavated to around 20 mAOD with a water level of around 24 mAOD, while the central sump is excavated to around 21 mAOD with a water level of around 29 mAOD. Water is intermittently pumped from these sumps to a sump in the north west of the quarry where it soaks away.

It is planned that the Quarry will ultimately be worked to –20 mAOD in line with the existing planning permission.

For reasons explained in Chapter 1.0 of the main ES (SLR, 2014), the respective applications have not been determined, and there is a requirement to undertake further updated EIAs and to present the results in updated formal ESs. The hydrological and hydrogeological elements of the EIA were based on the continuation and extension of current water management practices at the Quarry. A summary of the findings of the Hydrogeological ES is contained at Appendix F.

The ES includes a set of proposed planning conditions, including a requirement to continue the quarrying operations in accordance with a Water Management Plan (WMP), (ref SLR, 2014 Annex 1).

2.2 The Water Management Plan

The objective of the WMP is to guide the Quarry Operator in its management of water at the Quarry such that any adverse environmental impacts resulting from these activities can be minimised. In order to achieve this, the WMP will:

- Specify the monitoring activities required;
- Outline how the resultant data should be reviewed in order to determine whether the operation of the Quarry has affected any of the monitoring sites;
- Outline the options for management of water at the Quarry and how these could be adjusted in the light of any effects detected at any of the monitoring sites.

The Quarry Operator will operate the WMP until the ongoing monitoring and reporting under the WMP demonstrates that the need for mitigation measures as a result of the activities at the Quarry has ceased[2].

The determining authority under the ROMP procedure, and hence this document, is the Welsh Government, with Bridgend County Borough Council and Natural Resources Wales as statutory consultees. Following determination of the ROMP and formal adoption of the WMP, the regulatory body will become Bridgend County Borough Council (the Regulator) with Natural Resources Wales as statutory consultee.

Due to the commonality of issues, conditions for the adjacent Grove and Cornelly Quarries will be determined in parallel with those for Gaens Quarry. As a result, a separate WMP will be required for each quarry. Whilst there is a significant degree of overlap between the WMPs for the three quarries, they each form separate and independent documents. However, the respective WMPs are being prepared by the same hydrogeological consultant,

[2] See comments in Section 3.2 about the need for mitigation measures to continue after the end of dewatering.

using common data, the collection, analysis and interpretation of which has been jointly funded by the respective Quarry Companies.

2.3 This Document

This version of the WMP for the Quarry takes, into account the findings of latest version of the ES (SLR, 2014).

Figure 1 provides a flow diagram illustrating the main processes required in the WMP. This is for illustrative purposes only. The main text of this report provides the definitive description of the requirements of the WMP.

2.4 Future Amendments

It is intended that the WMP will be a 'living document' and will be operated over many years during which there are likely to be staff changes at both the Regulator and the Quarry Operator. It is important therefore that the WMP should be unambiguous and comprehensive. However, it should also contain appropriate mechanisms to allow it to be adapted and continue to be used successfully as conditions change in the future. The inclusion of measures to deal with certain eventualities does not necessarily indicate that such eventualities are viewed as being likely.

It is anticipated that the actions required under the WMP (e.g. monitoring locations, frequencies etc.) will need to be revised from time to time in the light of some of the data sets obtained and other factors affecting either the regulatory or hydrogeological environment. Changes to the actions required under the WMP require the agreement of both parties: the Regulator (in consultation with the relevant statutory consultees) and the Quarry Operator.

Note that it is expected that water quality standards for the water discharged from dewatering activities will be addressed by means of Discharge Consents which will be agreed separately with Natural Resources Wales.

3 WATER MANAGEMENT

3.1 Quarry Pumping (Operational Phase)

Throughout the remaining operational life of the Quarry, the dewatering system within the Quarry will continue to operate as it has done occasionally in the past, pumping from a basal sump to the northern quarry sump. During the process of deepening the base of the Quarry, it may be necessary to construct one or more temporary sumps before relocating the main sump down again.

The calculations carried out as part of the environmental impact assessment (Appendices 7.3 and 7.4 of SLR, 2014) indicate that average pumping rates off site from the Quarry will be around:

- 2443 m^3/d at 15 years (-0 mAOD).
- 2352 m^3/d at 42 years (-20mAOD).

These rates assume that Cornelly Quarry continues to discharge primarily to Grove Quarry. If Cornelly Quarry reverts to pumping to Pant Mawr quarry, then the rate required to dewater Gaens Quarry will increase.

These are average rates: clearly the rates required at any one time will depend on antecedent rainfall and quarry operational factors. The monthly average rate of pumping at Cornelly Quarry previously has varied by +/- a factor of two.

It is anticipated that, in future, the amount of variability around the mean monthly average rate is likely to be similar to that experienced in this area in the past. Where the pumping rate in the Quarry is significantly higher than that which would be expected given antecedent rainfall and quarry operations, this would trigger Contingency Measures (Section 8).

It is proposed that, once 12 months of higher frequency pumping rate data are available (i.e. August 2014), a Climate Based Assessment Criterion is developed for pumping rates at the quarry (ref section 6.3.3).

3.2 Quarry Pumping (Recovery Phase)

The period during which the quarry void fills with water after the end of quarry operations and dewatering has been identified in the ES as a period with potential for impact on surrounding water bodies, unless mitigation measures continue during the period required to restore groundwater equilibrium. The need to consider continued pumping out of the Quarry during this period until conditions have broadly stabilised is noted in the ES. The WMP has been written in a manner that will allow it to continue to guide the management of water on site during this period.

3.3 Discharge of Dewatering Water

From the basal sump, water is pumped off site as required. A single route is currently available for disposal of this water from the Quarry:

1. Pumping to the northern quarry sump

In the future it is possible that other options for the disposal of dewatering water may arise.

4 MONITORING REQUIREMENTS

4.1 Normal Monitoring Procedures

The Quarry Operator shall ensure that monitoring is carried out at the sites set out in Appendix A - Sections A.1, A.2, A.3 and A.4 of this WMP at the frequencies specified therein. The methods required to ensure the accuracy and representativeness of the data collected are set out in Appendix B. Procedures for managing any problems that it is anticipated could prevent the Quarry Operator from carrying out the required monitoring are set out in Section 4.2. The Quarry Operator and Regulator will work together to ensure that the functional integrity of the monitoring network is maintained.

In Appendix A, monitoring sites have been classified according to the purpose of monitoring at that site[3]:

- Source (monitoring of activities in and around the Quarry that could give rise to impacts on the surrounding groundwater systems – principally dewatering and disposal of water)
- Pathway (monitoring of sites between the Quarry and potential receptors to provide early warning of potential impacts)
- Receptor (monitoring of hydrogeological conditions at a potentially sensitive site)
- Background (monitoring that provides information that helps interpret trends observed at other sites – e.g. rainfall)

The purpose for which a site has been selected for monitoring is relevant in helping to decide a course of action if a site becomes unavailable for monitoring (Section 4.2.3) and is also relevant when considering what actions would be appropriate if a Deviation is deemed to have occurred at that site (Sections 6.2 and 6.3).

Table A.5 in Appendix A summarises other hydrometric monitoring that is being carried out in the area by third parties. Much of the data collected by third parties is of use in understanding the hydrogeological processes that are occurring in the area but does not form part of the requirements of this WMP. However, some datasets currently collected by third parties are identified as being of critical value to the operation of the WMP. These are highlighted in Bold in Appendix A, Table A.5 (third party monitoring) and duplicated in Sections A.1 to A.5 (monitoring for which the Quarry Operator is responsible).

All data collected as part of the WMP will be stored digitally by the Quarry Operator in an appropriate database system with an associated digital backup system (including off site storage of backup material). Digital copies of the data will be made available to the Regulator as part of the annual reporting process (Section 5.1). However, relevant digital data would also be made available to support discussion on Contingency Measures (Section 8) and/or upon reasonable written request by the Regulator.

4.2 Procedures for Managing Problems with the Monitoring Network

Appendix A sets out the monitoring required under this WMP. As this monitoring will need to be carried out over many decades, it is anticipated that a range of practical problems may be encountered in the future. The section below sets out procedures that should apply when such problems are encountered.

The overall objective of the procedures in this section is to ensure that the network be maintained by the Quarry Operator at an appropriate level of functionality to allow the WMP to operate effectively. This requires a balance to be struck such that the need to ensure that

[3] Sites in Tables A.1 and A.4 are all Source monitoring sites, Sites in Table A.3 are all Receptor monitoring sites. In Tables A.2 sites are identified individually.

critical data are collected is achieved but that this does not introduce unreasonably onerous requirements on the Quarry Operator.

The monitoring requirements of the WMP may also need to be revised in future: a mechanism for identifying and agreeing the need for such changes is described in Section 5.1.

For each site in Table A.2 (which sets out the water level monitoring sites), the sites which current monitoring over the last 8 years has shown to have a good correlation with sites that have been identified as potential 'back up sites'. These sites could be appropriate alternative sites if data are lost at a site or if a site becomes unavailable for monitoring.

4.2.1 Missing data

The Quarry Operator will endeavour to ensure that all the monitoring specified in Appendix A is carried out each year. However, it is accepted that, even in well operated monitoring networks, there will be occasions on which data are not collected. Reasons for this include:

- Temporary inaccessibility of particular sites
- Other practical difficulties with recording data at a site
- Loss or corruption of data collected by data loggers

Experience at other equivalent sites with well managed hydrometric monitoring networks at which similar numbers of data loggers are employed indicates that it should be possible to achieve 90 to 95% of the target data collection across the whole network over the course of a year. The collection rate at individual sites would typically be 100% but, at a few sites, the rate of collection may drop below this (e.g. loss of one month's data would lead to a data collection rate of 92% at that site).

Given that missing data is an expected condition, it is important to have procedures in place to deal with the situation. The following procedures will therefore apply for losses at individual sites:

- Where data are lost because of problems during a particular month (i.e. all data for one monitoring round at a particular site), this shall be recorded by the Quarry Operator and reported in the annual review of data. This report will explain the reason for the loss and propose actions that will be taken to prevent future loss.
- If it becomes apparent that the period of data loss at a site will exceed 60 days (i.e. the problem will not be rectified by the end of the next monitoring round), the Quarry Operator will notify the Regulator of the situation within 5 working days of becoming aware of the potential data loss and will outline the measures that are being taken to rectify the situation.
- The Regulator will consider the Quarry Operator's proposals and may recommend alternative monitoring that should be carried out during the period when data continues not to be collected. Any such alternative monitoring that is recommended by the Regulator should be proportionate to the criticality of the potentially missing data for the purposes of implementing this WMP. The criticality of the dataset will be judged by two considerations:
    1. Whether there are any other datasets from nearby monitoring sites that have a good correlation with the dataset with missing data (see 'back up' sites identified in Table A.2). Where there are such alternative datasets that allow the behaviour of the system over the period of missing data to be reasonably estimated, the missing data will be viewed as being less critical.
    2. The degree to which the dataset represents conditions at a Receptor. A dataset that provides a good indication of conditions at a Receptor will be viewed as being more

critical than one which only provides information on the Pathway between the Quarry and a Receptor, particularly where there are other 'back up' Pathway sites.

Where the data losses apply to more than three sites in a particular period, this will trigger Contingency Measures (see Section 8).

4.2.2 Incorrect data

The QA measures outlined in Appendix B are designed to minimise the risk that data will be incorrectly recorded. The review elements of these QA measures and the annual data review (Section 5.1) should also help to identify where data have been incorrectly recorded. Where data are identified as being incorrect (or potentially incorrect) the Quarry Operator shall flag them as being as such in the database system. If information is available to allow the data to be corrected, this shall be carried out by the Quarry Operator. However, the Quarry Operator shall maintain a digital record of any corrections made so that any corrected data can be identified as such.

4.2.3 Site unavailable

It is not anticipated that access for monitoring Receptor monitoring sites will become a problem due to lack of access (it is in the interest of the owners/controllers of Receptors for the monitoring to take place and it would not be possible to initiate Mitigation Measures under this WMP unless data are available).

The majority of the Source and Pathway sites that the Quarry Operator is required to monitor (Appendix A, Sections A.1 to A.5) are either under direct control of the Quarry Operator, within the land under the control of one of the adjacent quarries that will have related Water Management Plans (Gaens and Grove), or on land controlled by a public body (e.g. Kenfig Pools and Dunes NNR). The remaining Pathway sites are relatively few in number (six). However, it is possible that, at some point in the future, one or more of the sites may become unavailable for monitoring.

If it becomes apparent that a site has become unavailable for monitoring (or permanently unsuitable for monitoring for any reason), the Quarry Operator will notify the Regulator of the situation within 21 days of becoming aware of the potential loss of the site and will outline any proposed alternatives.

The Regulator will consider the proposal being made by the Quarry Operator. The Regulator may either accept the Quarry Operator's recommendation or may recommend an alternative. Alternatives that could be considered in these circumstances are:

- Changing the monitoring frequency at an existing nearby, equivalent monitoring site (see 'back up' sites listed in Table A.2);
- Changing the monitoring requirement to an existing unmonitored site for which access would be available (Appendix D of Appendix 7.1); or
- Changing the monitoring requirement to a new site at which access would be available and at which an appropriate monitoring structure is not at the time installed. For Pathway sites, it is anticipated that any replacement sites should be within 300 m of the original site and ideally within the same geological formation.

Any alternatives that are specified should be proportionate to the criticality of the potentially missing data (see Section 4.2.1 for definition of criticality of datasets).

If the Regulator reasonably specifies that a new monitoring site needs to be introduced to the monitoring network, the Quarry Operator will use its reasonable endeavours to achieve the installation of the monitoring point within 6 months of agreement to do so. New monitoring sites will only be specified for locations at which the Quarry Operator can reasonably obtain access.

4.2.4 Cessation of third party monitoring

Natural Resources Wales has duties under various legislation (e.g. Habitats Directive, Water Framework Directive etc.) to protect and manage water related features that are of relevance to this WMP. In order to achieve this, Natural Resources Wales carries out monitoring activities in the area as listed in Appendix A (Table A.5). Bridgend County Borough Council is also responsible for monitoring at the Kenfig Dunes National Nature Reserve and there is some monitoring carried out at nearby landfill sites.

Some of the sites currently monitored by third parties have been identified as being of critical value to the operation of the WMP. These sites have been highlighted in Table A.5 and the critical water level monitoring sites are duplicated in Sections A.1 to A.5 (monitoring for which the Quarry Operator is responsible).

If the Quarry Operator becomes aware that a third party is no longer monitoring any of the critical sites listed in Table A.5 or that the QA methods applied by the third party at these sites are not adequate by reference to Appendix B, the Quarry Operator will notify the Regulator within 21 days that this is the case and suggest any appropriate actions.

The Regulator will consider the Quarry Operator's proposals and may recommend alternative monitoring that should be carried out by the Quarry Operator. Alternative monitoring that can be recommended in these circumstances is:

- Taking over the monitoring at the critical third party site (subject to access agreements being obtainable);
- Moving a data logger from another, less critical site to ensure that regular monitoring is still achieved at the third party site; or
- Changing the monitoring frequency at an existing nearby, equivalent site.

Any alternative monitoring that is specified should be proportionate to the criticality of the potentially missing data (see Section 4.2.1 for definition of criticality of datasets). In addition, no monitoring shall be recommended at sites to which the Quarry Operator does not have or cannot reasonably obtain access.

Measures that require the introduction of a new site to the monitoring network shall be dealt with under the procedures outlined in Section 4.2.3.

5 REVIEW AND REPORTING

5.1 Data Review and Annual Report

The Quarry Operator will carry out a review of the data collected by the Quarry Operator and third parties during each 12 month period from April to March. An annual data review report will be submitted by the Quarry Operator to the Regulator within 90 days of the end of the period under review (June). Achievement of this timescale will be assisted by third parties providing the data promptly.

The annual data review report will contain:

1. A description of any activities in the Quarry during this period that are relevant to local hydrogeological conditions. This will include presentation of data showing the rate of pumping from the quarry sump and the rate of pumping to adjacent discharge points together with plans of the Quarry showing the location of any sumps and the benches that have been worked during the period.
2. Assessment of quarry pumping rates against an appropriate Climate Based Assessment Criterion (Section 6.3.3).
3. Graphical presentation of all of the monitoring data collected at appropriate scales (e.g. for both the 12 month period and the full period of data availability).
4. Summary tables showing percentage completeness of data collection relative to target (as set out in Appendix A) together with a description of any difficulties encountered in collecting the data.
5. A concise summary of any incorrect or missing data that have been identified and how they have been treated.
6. Summary tables showing the range of values measured at each site during the 12 month period and how this compares to previous periods.
7. A summary of the condition of each monitoring point including comment on any possible change in datum levels and the recent plumbed depth of each borehole/dip well.
8. A concise summary of climatic conditions during the 12 month period and how this compares to previous periods.
9. A summary of any indications in the data that the conceptual model of the local hydrogeology needs to be adjusted and the significance of any such adjustments.
10. A comparison of the data collected at each site against the relevant Assessment Criteria (see Section 6.1 and 6.2).
11. An assessment of the significance of any Deviation (see Sections 6.2.2 and 6.3.2).
12. An assessment of the effects of any changes that have been made to the way in which the quarry discharges water over the previous 12 month period.
13. A description of any Contingency Measures (Section 8.0) that have been required during the previous 12 month period.
14. Recommendations for changes required to the monitoring network in order to support achievement of the objective of the WMP.
15. Recommendations for any adjustments to the Mitigation Measures (Section 7.0) being carried out supported as necessary by Appropriate Calculations (Section 6.6) to demonstrate that this will achieve the desired objective.
16. Recommended changes to the monitoring system to allow the effectiveness of any such changes to be monitored. During the Recovery Phase (Section 3.2), it is anticipated that this will include an assessment of how much residual pumping will be required to minimise any adverse environmental impacts.

17. An outline of any proposed developments that are scheduled to take place in the Quarry over the coming 12 months that have a bearing on the local hydrogeology (e.g. construction of new sumps, working of new benches, changes to pumping regime etc.) together with an assessment of likely effect on dewatering rates (i.e. a guide to likely dewatering rates under different rainfall scenarios).

18. A digital copy of all data collected during the course of the previous 12 months.

In addition, the Quarry Operator will provide a concise update report to the Regulator by the end of October of each year. This update report will provide a table showing the percentage completeness of data monitoring against target during the first 6 months of the year (April to September) and will also highlight if any Trigger Level Assessment Criteria have been breached or if any Contingency Measures have been reported in this period.

Copies of any reports issued will be sent direct to the relevant offices/departments of the Regulator and the statutory consultee (Natural Resources Wales).

5.2 Overview by the Regulator

The Regulator will review the annual report in detail and will write to the Quarry Operator within 90 days of receiving the report detailing:

- Acceptance or disagreement with the conclusions reached;
- Acceptance or disagreement with the recommendations made;
- Details of any recommendations that the Regulator requires for changes in the WMP, including a need for a change to the periodicity of review.

In the absence of any comment within the 90 day period, the Regulator will be deemed to have accepted the content, findings and recommendations of the annual report.

6 MECHANISM FOR DETERMINING WHETHER A DEVIATION HAS OCCURRED AND IDENTIFYING RESULTANT ACTIONS

6.1 Summary of Approach

Figure 1 illustrates the sequence of events in the procedure for determining whether a Deviation from an Assessment Criterion has occurred and whether any changes to the Mitigation Measures are required as a result. In summary, the following steps are required:

1. Compare the measured data at the monitoring site against the relevant Assessment Criterion (Appendix C);
2. If a Deviation is identified (6.2.1), assess whether that Deviation is a Significant Deviation (6.2.2);
3. Review the spatial pattern of Deviations, the behaviour of the groundwater system during the period in question and carry out Appropriate Calculations (6.6) to determine whether dewatering activities at the Quarry are a contributory cause to any Significant Deviations;
4. Identify any amendments required to the Mitigation Measures (7.0) and monitoring under the WMP.

Two different types of Assessment Criteria are used in this WMP: Trigger Levels (6.2.1) and Climate Based Assessment Criteria (6.3.1). Different procedures apply to these different approaches as described below. It is anticipated that, whilst only Trigger Levels have been set to date, there will be a migration towards Climate Based Assessment Criteria for many of the sites during the initial period of implementation of the WMP. Steps required to achieve this migration are described in Section 6.7.

6.2 Trigger Levels

6.2.1 Definitions

Trigger Levels are absolute values against which data can be compared. If any of the data measured at a Pathway or Receptor site[4] 'exceed'[5] the relevant Trigger Level, a Deviation has occurred. The proportion of the data in the period under review that has to 'exceed' the Trigger Level at a Receptor site before a Significant Deviation is considered to have occurred is defined in Section 6.2.2.

Trigger Levels are a relatively simple approach to setting Assessment Criteria and suffer from a limited ability to take into account antecedent climatic conditions which usually dominate the data being recorded. However, there are some sites for which Climate Based Assessment Criteria are not appropriate: this principally applies to shallow ponds and wells (e.g. ID 17, 20, 23 etc. in Table A.2) or sites affected by tidal variations (e.g. ID 21 in Table A.2). Trigger Levels have been developed for these sites, as set out in Appendix C.

6.2.2 Proportion of data to 'exceed' a Trigger Level Assessment Criterion before a Significant Deviation is considered to have occurred

Data derived from the monitoring of natural systems typically have a degree of 'noise' in them. The aim of this section is to define periods over which data have to 'exceed' a relevant Trigger Level Assessment Criterion before a Significant Deviation is considered to have occurred, so that the effects of such 'noise' in the data do not unnecessarily affect the water management at the Quarry.

[4] Deviation can only be defined for Pathway and Receptor monitoring sites. Source monitoring sites are by definition already significantly affected by Quarry dewatering. The zone over which dewatering at the Quarry is considered to have already significantly affected groundwater levels (estimated at 1.2 to 1.4 km^2) is discussed in the ES for the Quarry (SLR, 2014).
[5] Note, trigger levels may either be minimum values or maximum values. In the former case, 'exceed' in this context means to fall below, in the latter case, to fall above.

Where a pre-defined proportion of the data measured at a Receptor Site 'exceed' a relevant Trigger Level Assessment Criterion during the period under review, it will be considered that a Significant Deviation has occurred. The relevant proportions of the data are defined as follows:

- For a water level monitoring site monitored by a data logger at daily intervals (or more frequently), the proportion is 10% of values measured during the 12 month period under review.
- For a water level monitoring site monitored manually at monthly intervals, the proportion is two consecutive values measured during the 12 month period under review.

Similar proportions will be derived for stream and spring flow data series once a representative period of time series data has been collected (See Section 6.7).

If it appears, by reference to a Trigger Level, that a Significant Deviation has occurred, it may be appropriate to develop a Climate Based Assessment Criterion for that site to confirm this conclusion. However, this should not delay the issue of an annual report or the conclusion as to whether a Significant Deviation has occurred at that site.

6.3 Climate Based Assessment Criteria

6.3.1 Definitions

A Climate Based Assessment Criterion is a calculation that allows the 'natural' behaviour of a monitoring site under different climatic conditions to be estimated. The approach that will be used to calculate these Climate Based Assessment Criteria is outlined in Appendix D.

Deviation from a Climate Based Assessment Criterion is defined as the occurrence of a statistically significant difference between the behaviour measured at a Pathway or Receptor Site[6] and the behaviour predicted by the relevant Climate Based Assessment Criterion. The statistical approaches that will be used to determine the presence and size of any Deviation between the observed data and the Climate Based Assessment Criteria are described in Appendix D.

The Climate Based Assessment Criterion for a site needs to be calibrated against a 'baseline' - observed data from that site for a period over which it can be agreed that there are no significant effects of water management at the Quarry on the observed data (or if there are such effects, that correction can be made for them). As with all models of natural systems, there will be some variance between the simulated and observed values. The size of this variance will determine both the confidence that can be placed in the Climate Based Assessment Criterion for that site and also the minimum difference between the simulated and observed data that could be considered to be statistically significant.

6.3.2 Assessment of the significance of a Deviation at a Receptor Site

Where a Deviation has been determined at a Receptor Site by means of a Climate Based Assessment Criterion, the Quarry Operator will assess the significance of the Deviation by reference to the sensitivity of that Receptor. The following Sensitivity Criteria will be used for determining whether a Deviation relative to a Climate Based Assessment Criterion at a Receptor site is a Significant Deviation.

- For licensed groundwater abstraction boreholes, a groundwater level reduction in excess of 0.5 m relative to the relevant Assessment Criterion is taken to indicate a potentially significant impact unless further assessment (i.e. evaluation of borehole construction details, pump intake level etc.) indicates that this has not materially affected the functioning of the supply.

[6] Deviation can only be defined for Pathway and Receptor monitoring sites. Source monitoring sites are by definition already significantly affected by Quarry dewatering. The zone over which dewatering at the Quarry is considered to have already significantly affected groundwater levels (estimated at 1.2 to 1.4 km^2) is discussed in the ES for the Quarry (SLR, 2014).

- For shallow wells, a groundwater level reduction in excess of 0.25 m relative to the relevant Assessment Criterion is taken to indicate a potentially significant impact unless further assessment indicates that this has not materially affected the use or value of the well.
- For ponds (excluding Kenfig Pool and any dune slacks in Kenfig Pool and Dunes and Merthyr Mawr SAC) the criteria will be agreed with the Regulator, but have provisionally been set as a change of 0.1 m relative to the relevant Assessment Criterion for each of the ponds monitored (sites 17, 20 and 23 in Appendix A, Table A.2) unless further assessment indicates that this has not materially affected the use or value of the pond.
- For spring flows, a reduction of flow in excess of 10% of mean long term flows relative to the relevant Assessment Criterion is taken to indicate a potentially significant impact unless further assessment indicates that this has not materially affected the use or value of the spring.
- Natural Resources Wales has requested that the Sensitivity Criterion for groundwater level changes at Kenfig Pool and Dunes and Merthyr Mawr SAC is set at a reduction in average summer water levels in the dune sands of 0.1 m relative to the relevant Assessment Criterion over a period of three or more years. Summer is defined as the period between July and October each year (inclusive).
- Natural Resources Wales has not identified a Sensitivity Criterion for changes in water level in Kenfig Pool. For the purposes of this WMP it is assumed that the same Sensitivity Criterion as for the adjacent groundwater levels (i.e. 0.1 m fall in summer levels relative to the relevant Assessment Criterion over 3 years) will apply.

6.3.3 Assessment of the significance of a change in quarry pumping rate

The Scoping Direction requires assessment of:

> *the potential impact of quarrying on hydrology and hydrogeology of the area, including the possibility of interception during quarrying of a 'highly permeable feature' within the limestone, and although there is a low probability of this occurring the prospect should be recognised as a continuing risk during further development of the quarry and appropriate action identified (for example a risk management/ monitoring strategy which recognises the critical stage at which potential adverse impact may occur);*

Discussion with Natural Resources Wales has indicated that an appropriate way of managing this risk is to focus on regularly determining whether the pumping rate in the quarry is in the range anticipated.

It is anticipated that it will be possible to develop a Climate Based Assessment Criterion for the quarry pumping rate once at least 12 months of weekly data is available . Comparison of the observed pumping rate with the rate predicted by the Climate Based Assessment Criterion will form part of annual reporting (Section 5.1).

A substantial difference between observed and predicted pumping rates would trigger Contingency Measures (Section 8). The percentage difference that would trigger Contingency Measures will need to be assessed once the quality of the Climate Based Assessment Criterion for the quarry pumping rate has been developed.

6.4 Identification of the Cause of Deviations and Significant Deviations

As part of the annual report (Section 5.1), the Quarry Operator will review the spatial distribution of any Deviations and/or Significant Deviations (collectively "deviations" in the text below) that have been identified in the 12 month period under review with the aim of identifying their cause. In addition, the Quarry Operator will also review the available monitoring data and assess whether it is likely that any deviations are likely to occur in the next 12 month period.

If any deviations have occurred or are considered likely to occur, three possible outcomes of this review are anticipated:

1. The pattern of Deviations clearly indicates that water management at the Quarry is a contributory cause of the deviations. In this circumstance, the Quarry Operator will identify appropriate changes to the Mitigation Measures as described in Sections 6.5 and 7.0.
2. The pattern of Deviations clearly indicates that water management at the Quarry is not a contributory cause of the Deviations. In this case, the Quarry Operator will report this finding to the Regulator for its attention and no further action is required under Section 6.5 below. The Regulator will review this conclusion as part of its review of the annual report (Section 5.2). If the Regulator does not agree with this conclusion, it will set out its reasons for disagreeing and/or make a reasonable request further information or Appropriate Calculations that, in its view, will help to determine the cause of the Deviations.
3. The pattern of Deviations does not clearly indicate whether water management at the Quarry is a contributory cause of the Deviations. In this case, the Quarry Operator will carry out Appropriate Calculations (Section 6.6) to determine the most probable degree to which dewatering at the Quarry is the cause of the Deviations.
    a. If the Appropriate Calculations indicate that water management at any of the Cornelly Group of Quarries is not a contributory cause of the Deviations, the Quarry Operator will report this finding to the Regulator for its attention.
    b. If the Appropriate Calculations indicate that water management at another of the Cornelly Group of Quarries is a contributory cause of the Deviations, the Quarry Operator will report this finding to the regulator and the relevant Quarry Operator for implementation via the relevant WMP.
    c. If the Appropriate Calculations indicate that water management at the Quarry is a contributory cause of the Deviations, the Quarry Operator will identify appropriate changes to the Mitigation Measures as described in Section 6.5.

6.5 Identifying actions required in the case of a Significant Deviation occurring at a Receptor monitoring site

Where a Significant Deviation has been identified, as part of the annual report the Quarry Operator will recommend adjustments to the Mitigation Measures (Section 7). These adjustments should be proportionate to the degree to which the Quarry is a contributory cause of the Significant Deviation. The Quarry Operator will support the proposed adjustments to the Mitigation Measures by means of Appropriate Calculations (Section 6.6).

6.6 Appropriate Calculations

Some parts of the WMP require Appropriate Calculations to be carried out. For instance:

- Calculations to develop Climate Based Assessment Criteria (Section 6.3).
- Calculations required to clarify the extent to which dewatering at the Quarry is the cause of a Deviation (Section 6.4);
- Calculations to assess whether a Deviation is likely to occur at a Receptor monitoring site in the next 12 months (Section 6.4); and
- Calculations to demonstrate the likely effectiveness of proposed adjustments to Mitigation Measures (Section 6.5).

Appropriate calculations can include some or all of the following:

- Simple scoping calculations using appropriate analytical and mass balance equations
- Time series recharge calculations such as those presented in Appendix D;

- More complex calculations such as the Flow Network Model presented in Appendix 7.3 of SLR, 2014 (included as Appendix E of this document for completeness);
- Distributed numerical groundwater modelling of all or parts of the system.

The complexity of the calculations applied will be discussed and agreed with the Regulator (and the relevant statutory consultees) and will be proportionate to the significance of the impacts being considered and the actions required as a result of the calculations.

6.7 Steps for Migration of Assessment Criteria

Sites for which Assessment Criteria are required are the Pathway and Receptor sites listed in Appendix A, Table A.2 and all the sites in Appendix A, Table A.3.

This section sets out a series of steps required to migrate from the current position (in which all Assessment Criteria are Trigger Levels as set out in Appendix C), to the future position at which the majority of sites are assessed by reference to Climate Based Assessment Criteria.

6.7.1 Sites for which more than three years' data are available and calculations for a generic Climate Based Assessment Criteria have already been developed

The majority of sites listed in Table A.2 have been monitored for over ten years. In addition, generic calculations of the kind required for calculation of Climate Based Assessment Criteria under Appendix D have previously been presented (e.g. WynThomasGordonLewis, 2004) and reviewed in detail by Natural Resources Wales. Climate Based Assessment Criteria for these sites are presented in Appendix C.

6.7.2 Sites for which more than three years' data are available but for which Climate Based Assessment Criteria are not appropriate

Climate Based Assessment Criteria may not be appropriate for a few of the sites listed in Appendix A, Table A.2. This principally applies to shallow ponds and wells (e.g. ID 17, 20, 23 etc. in Table A.2) or sites affected by tidal variations (e.g. ID 21 in Table A.2). For these sites it is appropriate to retain Trigger Level Assessment Criteria as discussed in Appendix C unless a more accurate method can be developed.

6.7.3 Sites for which less than three years' data are available

This principally refers to the stream monitoring sites listed in Appendix A, Table A.3. During the time period when an appropriate dataset to allow Climate Based Assessment Criteria to be developed for these sites is being collected (2014-2017), conditions will be assessed by reference to the Assessment Criteria for nearby water level monitoring sites as follows:

HL 13, 14 and 15 –assessed using data from sites G, I, L. D4, D7 and D8.HL11 – assessed using data from sites T_96/11 and T_95/01

HL6 – assessed using data from sites C and D.

7 MITIGATION

7.1 Mitigation Measures

The Mitigation Measures available under the terms of this WMP are:

1. Pumping to existing Sump within the Quarry. This would be with the aim of raising groundwater levels on the pathway to Kenfig Pool and Dunes SSSI;

No other sites for Mitigation Measures are currently available to the Quarry Operator. If other options arise in the future, they will be built into later versions of the Water Management Plan.

In the case of a Significant Deviation occurring at a private water supply (as listed in Appendix A, Table A.2, Mitigation Measures may also include:

2. Modification to the structure of the private water supply to minimise or remove the impact (e.g. deepening a well or borehole or lowering the pump);
3. Provision of an alternative mains water supply; or
4. Financial compensation for the loss of the water supply.

In the event of a quarry off-site discharge failing to meet the terms of the relevant discharge consent, potential mitigation measures include dilution within the large volumes of water held in various quarries and simple options for treatment such as aeration etc.

7.2 Implementation of Mitigation Measures

The Quarry Operator will make reasonable endeavours to implement any recommended adjustments to the above Mitigation Measures within 6 months of agreement of the measures. As part of the implementation of Mitigation Measures, the Quarry Operator will submit details of any adjustments to the monitoring programme in Appendix A that are required in order to determine the effectiveness of the Mitigation Measures (See Point 15 in Section 5.1).

If the Deviation is large enough to cause the interruption of water supply at a private water source then the Quarry Operator will respond within five working days (see Contingency Measures).

8 CONTINGENCY MEASURES

Contingency Measures are actions that may be required under the WMP in circumstances where events occur that were not predicted in the previous annual report and that require actions to be carried out before the next 12 month data review is complete (excluding the generally anticipated difficulties with any monitoring network defined in Section 4.2).

The following events will trigger Contingency Measures:

- An increase of the monthly quarry pumping rate so that it exceeds the maximum rates predicted in the relevant Climate Based Assessment Criterion by more than an agreed percentage (see Section 5.1);
- Intersection of a fissure in the quarry floor that yields large quantities of water;
- Occurrence of any signs of significant ground instability in and around the Quarry that could reasonably be attributed to activities in the Quarry;
- The loss of monitoring data at more than three sites in a particular month due to the same cause (e.g. failure of central data logger system);
- The loss of water supply from a private water supply that has been identified in the Gaens ES (SLR, 2014) as being potentially vulnerable to changes in water management activity at Gaens quarry;
- A marked change in the behaviour of a Pathway or Receptor monitoring site relative to previous behaviour at that site such that it is reasonable to expect that a Significant Deviation has occurred.

Other events in the Quarry that can reasonably be considered by the Quarry Operator or Regulator to be likely to affect the local groundwater systems rapidly in ways that were not anticipated at the time of the issue of the previous annual report will also trigger Contingency Measures.

The Quarry Operator will notify the Regulator of the occurrence of such an event within five working days of becoming aware of its occurrence. Within 21 days of notifying the Regulator of the occurrence of such an event, the Quarry Operator will inform the Regulator of the steps which it intends to take in response to an event, with, where appropriate, a list of proposed Contingency Measures, and a timetable for implementing those measures.

In the case of loss of water supply from a private water supply, the Quarry Operator will investigate the reason for the loss of supply and, if it is attributable to water management activities in Gaens quarry will make arrangements to provide an alternative or back up supply within five working days as a short term measure. After this, the normal Contingency Measures procedure will apply.

Contingency Measures may include:

- Additional monitoring of water levels, pumping rates or water quality;
- Changes to the way water is managed within the Quarry (see Sections 3 and 7);
- Other physical measures to minimise the problems encountered.

The Quarry Operator will also provide the Regulator with a digital copy of any data from the hydrometric network described in Appendix A that may be required by the Regulator in relation to the proposed Contingency Measures.

9 REFERENCES

SLR, 2014. Environmental Statement Volume 1 Environment Act Romp Review: Gaens Quarry

WynThomasGordonLewis, 2004. Environment Act 1995: Review of Mineral Planning Permissions Cornelly Quarry Environmental Impact Assessment

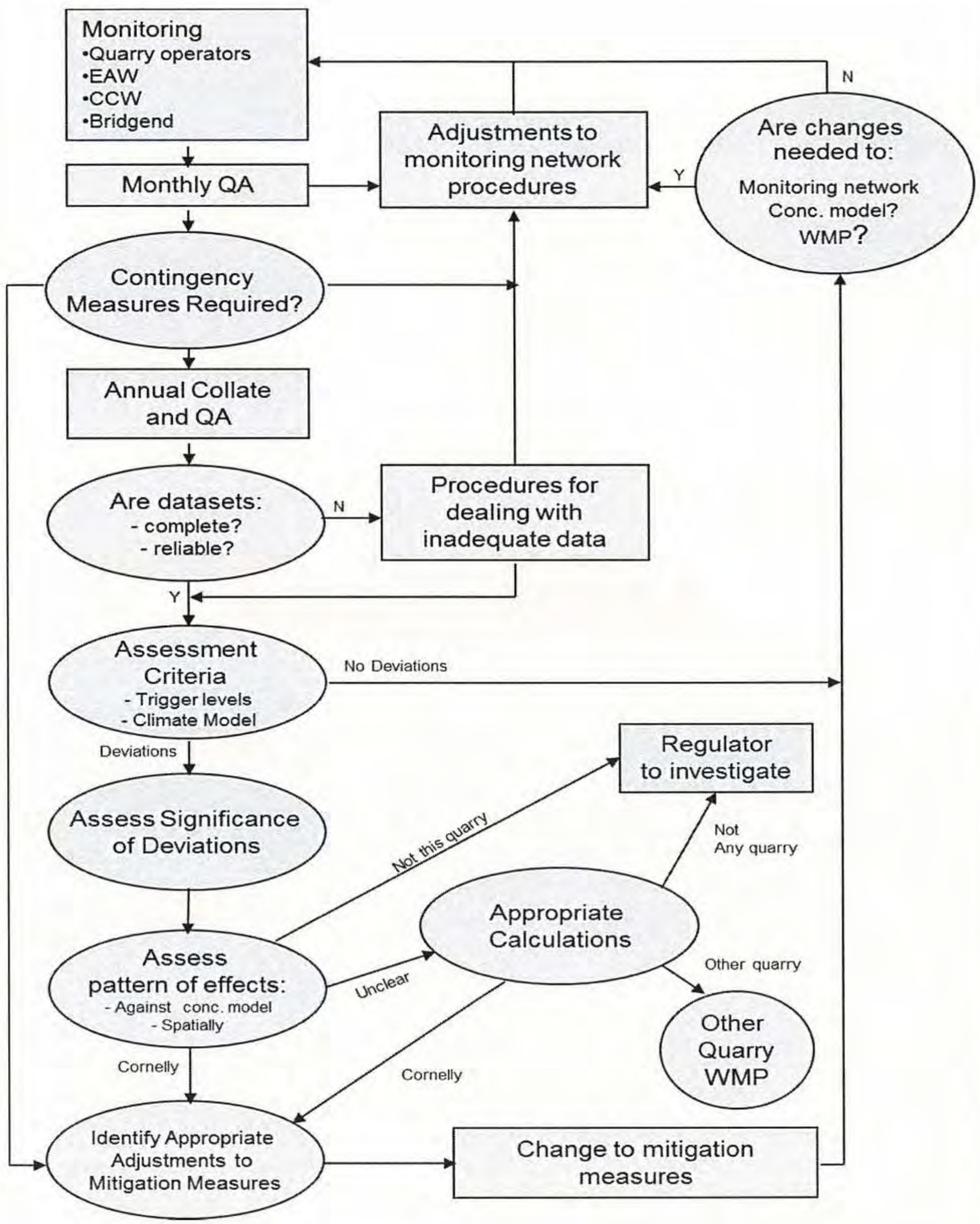


Figure 1
Illustrative flow chart showing processes required for Gaens IDO WMP

Date: Mar 14	Drawn: MJS
Scale: dns	Checked: MJS
Original: A4	Revision: 3
File Reference: O:\6227_Cornelly\reports\R17 EIA\Outline flow chart.xls	

esi soil & groundwater

APPENDICES

Appendix A Monitoring Requirements

A.1 Pumping Rates

The Quarry Operator will record the reading on the impellor flow meters installed on the various pumps in the Quarry on a weekly basis. The number of pumps being used will depend on the precise water management activities in the Quarry at the time. However, the Quarry Operator should measure the following flows if pumping has occurred to that site in the previous weekly period.

Table A.1 Abstraction Rate Monitoring (Source)

Site	Comment
Pumping from eastern quarry sump to central sump	Currently intermittent. A flow meter needs to be installed.
Pumping from central quarry sump to north western sump	Currently intermittent A flow meter needs to be installed.

A.2 Water Levels

The Quarry Operator will monitor water levels at the sites and frequencies set out in Table A.2. Locations of these sites are shown on Figure A.1.

Table A.2 Water Level Monitoring (Source, Pathway & Receptor Sites)

ID	Name/Setting	Type	Receptors being protected	Potential Backup Sites	Land controlled by[1]	Frequency	Comment	WMP[2]
14	Royal Porthcawl Golf Club	Receptor	14	36, 40	Golf course	Monthly	Private water supply	GR
17a	Ty Tanglwyst Farm	Receptor	17a, 17b	D	Private	Monthly	Private water supply	GR, C
17b	Well	Receptor	17a, 17b	D	Private	Monthly	Abstraction borehole. Pumping affects level.	GR, C
20	Wilderness	Receptor	20, 23	21, 23	Bridgend CBC	Monthly	Pond	GR, C
21	White Wheat	Receptor	21, 20, 23	20, 23	Private	Monthly	Private water supply. Tidal fluctuations.	GR, C
23	Pwll y Waun	Receptor	20, 23	20, 21	Bridgend CBC	Monthly	Pond	GR, C
34	Pond	Receptor	34, 61, Merthyr Mawr	G, 61	Private	Monthly	Pond	C
40	Grove Golf Club	Receptor	40, 14, 36, 18b	RWC100	Golf course	Monthly	Private water supply	GR
65	Kenfig Golf Club	Receptor	65	B, C	Golf course	Monthly	Private water supply	GR
A-a	Triassic	Pathway	Kenfig	B-a, C, N	Golf course	Daily		GR, C
A-b	Gravels	Pathway	Kenfig	B-b, K1a, K2a	Golf course	Daily		GR, C
B-a	Triassic	Pathway	Kenfig	A-a, C, N	Golf course	Monthly		GR, C
B-b	Sands		Kenfig	A-b, K1a, K2a	Golf course	Monthly	Perched (for info only)	GR, C
C	Limestone	Pathway	Kenfig, New Mill Farm Springs	A-a, B-a, N	Golf course	Daily		GR, C

CC_5[1]	Kenfig dunes	Receptor	Kenfig	CC_9, K1b, K2b, K4b	Kenfig Corp	Monthly	Apex of groundwater 'dome' in dune slacks	GR, C
CC_9[1]	Kenfig dunes	Receptor	Kenfig	CC_5, K1b, K2b, K4b	Kenfig Corp	Monthly	Western side of groundwater 'dome' in dune slacks	GR, C
D	Limestone	Source/ Pathway	New Mill Farm Springs Kenfig	17a, 17b	Rees & son	Monthly	May be affected by discharge of dewatering water nearby	GR, C
E	Limestone	Source/ Pathway	New Mill Farm Springs Railway Springs	Q	Rees & son	Monthly	Does not appear to have been affected by dewatering at Gaens yet.	
GAS	Gaens' Sump	Source	Mitigation measures	n/a	Rees & son	Monthly		GR, C
H	Limestone	Pathway	20, 21, 23	21	Private	15 minutes		GR, C
K1a	S&G aquifer	Pathway	Kenfig	K2a, N, A-a	Kenfig Corp	Monthly		GR, C
K1b	Dunes	Receptor	Kenfig	CC_5, CC_9, K2b, K4a	Kenfig Corp	Monthly	Dunes west of KP	GR, C
K2a	S&G aquifer	Pathway	Kenfig	K1a, N, A-a	Kenfig Corp	Monthly	Pathway to Kenfig (S&G aquifer)	GR, C
K2b	Dunes	Receptor	Kenfig	CC_5, CC_9, K1b, K4a	Kenfig Corp	Monthly	Dunes south west of KP	GR, C
K4a	Dune sand bh	Receptor	Kenfig	CC_5, CC_9, K1b, K2b	Kenfig Corp	Monthly	Apex of groundwater 'dome' in dune slacks	GR, C
K4b	Glacial Till	Pathway	Kenfig	n/a	Kenfig Corp	Monthly	Pathway to Kenfig (S&G aquifer)	GR, C
KP[1]	Kenfig Pool	Receptor	Kenfig	K1b, K2b, CC_5, CC_9	Kenfig Corp	Monthly		GR, C
N	Limestone	Pathway	Kenfig	K1a, K2a, A-b, B-b	Private	Daily	Note – piezometers installed at 3 levels in this hole but all currently show almost	GR, C

							exactly the same level	
O	Triassic	Pathway	New Mill Farm Springs	R	Kenfig Corp	Monthly	GW levels near springs	GR
P	Limestone	Pathway	New Mill Farm Springs		Highways Agency	Monthly	Pathway to springs	GR
PM	Pant Mawr	Source	Mitigation measures	n/a	Tarmac	Monthly		GR, C
Q	Limestone	Pathway	New Mill Farm Springs		Highways Agency	Monthly	Pathway to springs	
R	Triassic	Pathway	New Mill Farm Springs	O	Kenfig Corp	Monthly	GW levels near springs	GR

1. These sites are currently monitored by third parties. These are considered to be the most critical data sets collected by third parties and require a rapid response by the Quarry Operator should third party monitoring cease. Note that whilst Grove is currently operated by Lafarge Tarmac, the monitoring is treated as third party as this could conceivably change in future.
2. Sites that are subject to other WMPs are noted (–CN - Cornelly, GR - Grove')

It is assumed that as part of the separate water management plans for Cornelly Quarry and Grove Quarry there will be a requirement for water monitoring at sumps within respective operational quarry areas, and that the information arising from such monitoring will be disseminated between the Quarry companies as a continuation of the current joint approach to assessing the hydrogeological effects of both the individual and cumulative quarrying operations.

Monitoring of Receptors is subject to the agreement of the owners of the site and it is assumed that, as the monitoring is in their interest, this can be arranged by the Quarry Operator without any excessive penalties. Monitoring has only been proposed at those Receptors at which effects have been predicted from the proposed activities at the Quarry (SLR, 2014).

Monitoring at some of the Pathway sites is subject to ongoing agreements with the relevant landowners. These agreements cannot be guaranteed by the Quarry Operator in the long term. Procedures for dealing with a site that becomes unavailable for monitoring are given in Section 4.2.3.

The reference datum of each water level monitoring site will be re-surveyed at ten year intervals or at any point at which there is a step change in monitored water levels which might indicate that the datum has changed.

The depth of each borehole or dip well will be checked annually immediately prior to the issue of the Annual Report.

A.3 Surface Water Flows

The network of surface flow monitoring sites is shown on Figure A.1 and listed in Table A.3. All of these sites are defined as Receptor Monitoring Sites.

Table A.3 Stream Flow Monitoring

ID	Name	Type	Frequency
HL 6	Afon Fach	Stream	Monthly in summer
HL9a	New Mill Farm springs	Stream	Monthly in summer
HL9b	New Mill Farm springs	Stream	Monthly in summer
HL 11	Stormy Spring	Ephemeral Spring	Monthly in winter

Note: Summer in the context of this table includes the period April-September each year. Winter includes the period October to March.

A.4 Rainfall (Background)

The Quarry Operator will monitor rainfall in the Quarry by means of a tipping bucket raingauge linked to a data logger to allow values to be measured at 15 minute intervals.

Rainfall is also monitored by Natural Resources Wales at Schwyll STW, Cefn Cribwr and Margam and by Bridgend County Borough Council at Kenfig (see more details of these sites in Appendix D). Until the Quarry Operator has collected sufficient data from the new rain gauge to allow a good correlation with data from these existing sites, for the purposes of understanding the relationship between current rainfall and historical rainfall, continuation of monitoring at these sites by third parties is essential to the operation of the WMP.

A.5 Groundwater Quality

Water samples will be collected as set out in Table A.4.

Table A.4 Water Quality Monitoring Sites

ID	Name	Type	Frequency	Sampling Method
GAS	**Gaens Sump**	**Source**	**Monthly**	**Pumped/sump**

Each sample will be analysed for the following parameters:

Field Parameters — Temp, EC, pH, Alkalinity

Laboratory Determinands — Major Ions (Ca, Mg, Na, K, Cl, HCO_3, SO_4, NO_3, NH_4, Sr)

A.6 Monitoring by Third Parties

Some hydrometric monitoring is carried out in the area by third parties as listed in Table A.5. The locations of these sites are shown on Figure A.1.

Whilst the data from most of these sites is not critical to the WMP, the continuation of this monitoring is of benefit in providing additional information on the hydrogeological conditions in the area. Third party data that are considered to be critical to the operation of the WMP are highlighted in **Bold** in Table A.5. These sites are duplicated in Sections A.2 to A.4 as appropriate.

Table A.5 Monitoring by Third Parties

ID	Name	Monitoring Activity	Frequency	Third Party
GRS	**Grove Quarry Sump**	**Pumping Rates**	**-**	**Quarry Operator**[1]
GRS	**Grove Quarry Sump**	**Water Level**	**-**	**Quarry Operator**[1]
CS	**Cornelly Quarry Sump**	**Pumping Rates**	**-**	**Quarry Operator**[2]
CS	**Cornelly Quarry Sump**	**Water Level**	**-**	**Quarry Operator**[2]
SC	South Cornelly	Water Levels	15 minutes	Environment Agency
KP	**Kenfig Pool**	**Water Levels**	**15 minutes**	**Environment Agency**
	Schwyll Spring rain gauge	**Rainfall**	**Daily**	**Environment Agency**
	Cefn Cribwr rain gauge	**Rainfall**	**Daily**	**Environment Agency**
	Margam rain gauge	**Rainfall**	**Daily**	**Environment Agency**
CC_3,2	**Kenfig rain gauge**	**Rainfall**	**Weekly**	**Nature reserve staff**
I_BH18	Tythegston Landfill	Water Levels	Monthly	Landfill operator
I_COTTAGE	Tythegston Landfill	Water Levels	Monthly	Landfill operator
I_ROAD	Tythegston Landfill	Water Levels	Monthly	Landfill operator
I_TUSCA	Tythegston Landfill	Water Levels	Monthly	Landfill operator
I_WOODS	Tythegston Landfill	Water Levels	Monthly	Landfill operator
CC_1	Kenfig Dunes	Water Levels	Monthly	Bridgend BCC
CC_2	Kenfig Dunes	Water Levels	Monthly	Bridgend BCC
CC_24e	Kenfig Dunes	Water Levels	Monthly	Bridgend BCC
CC_3	Kenfig Dunes	Water Levels	Monthly	Bridgend BCC

ID	Name	Monitoring Activity	Frequency	Third Party
CC_3,2	Kenfig Dunes	Water Levels	Monthly	Bridgend BCC
CC_3,2	Kenfig Dunes	Rain Gauge	Twice weekly	Bridgend BCC
CC_3,2a	Kenfig Dunes	Water Levels	Daily	Bridgend BCC
CC_34	Kenfig Dunes	Water Levels	Monthly	Bridgend BCC
CC_4	Kenfig Dunes	Water Levels	Monthly	Bridgend BCC
CC_5	**Kenfig Dunes**	**Water Levels**	**Monthly**	**Bridgend BCC**
CC_6	Kenfig Dunes	Water Levels	Monthly	Bridgend BCC
CC_6,1	Kenfig Dunes	Water Levels	Monthly	Bridgend BCC
CC_7	Kenfig Dunes	Water Levels	Monthly	Bridgend BCC
CC_8	Kenfig Dunes	Water Levels	Monthly	Bridgend BCC
CC_9	**Kenfig Dunes**	**Water Levels**	**Monthly**	**Bridgend BCC**
CC_10	Kenfig Dunes	Water Levels	Monthly	Bridgend BCC
CC_11	Kenfig Dunes	Water Levels	Monthly	Bridgend BCC
CC_117	Kenfig Dunes	Water Levels	Monthly	Bridgend BCC
CC_12	Kenfig Dunes	Water Levels	Monthly	Bridgend BCC
CC_139	Kenfig Dunes	Water Levels	Monthly	Bridgend BCC
CC_A0124	Kenfig Dunes	Water Levels	Monthly	Bridgend BCC
D1	Sewage treatment plant	Water Levels	Monthly	CCW
D2	Candleston Stream	Water Levels	Monthly	CCW
D3	Slack3	Water Levels	Monthly	CCW
D4	**Slack2**	**Water Levels**	**Monthly**	**CCW**
D5	Slack1 East	Water Levels	Monthly	CCW
D6	Slack1 mid	Water Levels	Monthly	CCW
D7	**Flood plain**	**Water Levels**	**Monthly**	**CCW**
D8	**Slack1 West**	**Water Levels**	**Monthly**	**CCW**

1. At present Grove Quarry is not operational. The Quarry Operator is Lafarge Tarmac Ltd. In future Grove Quarry will operate under its own WMP. The Monitoring requirements of that WMP have not been set yet.
2. At present there is no dewatering ongoing at Gaens Quarry. The Quarry Operator is Rees and Sons. In future Gaens Quarry will operate under its own WMP. The Monitoring requirements of that WMP have not been set yet.

Procedures for the situation where a third party ceases to monitor a site or does not make the information available or where the Quarry Operator considers that the QA procedures being applied do not conform to the requirements of Appendix B are set out in Section 4.2.4 of the WMP.

Some additional hydrometric monitoring will be carried out in the area by third parties under different WMPs (Cornelly and Gaens Quarry Operators) as listed in Table A.6. The locations of these sites are shown on Figure A.1.

Table A.6 Additional Monitoring by Third Parties Under Different WMPs

ID	Name	Monitoring Activity	Frequency	WMP*
18b	Ty Talbot Farm	Water Level	Monthly	G
20	Wilderness	Water Level	Monthly	C
21	White Wheat	Water Level	Monthly	C
23	Pwll y Waun	Water Level	Monthly	C
34	Pond	Water Level	Monthly	C
61	Tynycaeau	Water Level	Monthly	C
CP	Cornelly Pond/GB	Water Level	Monthly	C
CS	Cornelly Sump	Water Level	Monthly	C
G		Water Level	Monthly	C
GRS	Grove Sump	Water Level	Monthly	G
L		Water Level	Monthly	C
Na	Well	Water Level	Logger - needed	C
RWC100		Water Level	Monthly	G
RWC105		Water Level	Monthly	G
RWC106		Water Level	Monthly	G
S		Water Level		C
T	Newton	Water Level	Monthly	C
T_95/01	Airfield	Water Level	Logger - installed	C
T_95/04	Stormy Down Quarry	Water Level	Monthly	C
U		Water Level	Monthly	C
HL13	spring in valley by dunes	Stream Gauging	Monthly in winter	C
HL14	by dunes carpark	Stream Gauging	Monthly in winter	C
HL15	Burrows well	Stream Gauging	Logger installed	C
CS	Cornelly sump	Water quality	Monthly	C
GAS	Grove sump	Water quality	Monthly	G

* Sites that are subject to other WMPs are noted (C-Cornelly, G-Grove')

Appendix B Quality Assurance (QA) Requirements

A rigorous approach will be adopted to ensuring the quality of all data collected during the monitoring period.

B.1 General Procedures

Quarry Abstractions: New meters have been fitted at the site and discussion with the manufacturers has indicated that the meters are within their calibration period. Meters will be re-calibrated as recommended by the manufacturers.

Water Levels: All monitoring datum points have been accurately surveyed in. All recent boreholes have been logged in detail (using geophysics in many cases) and constructed over selected intervals. A carefully designed field monitoring sheet is used for all field records (see example sheet). Water levels measured by data loggers are compared with manual readings on a monthly basis and any differences recorded and the loggers re-set. Water level measurements will comply with relevant sections of BS 6316: 1992.

A backup resource of two data loggers will be maintained to ensure continuity of monitoring.

Water Quality: All field measurements will be carried out to a standard specification using calibrated instruments. Laboratory analysis will be carried out by UKAS accredited laboratories.

Stream Flow Monitoring: The stream gauging exercise will be carried out as prescribed in BS 3680 Part 3Q: 1993.

An important part of QA for any monitoring network is regular review of the data (see Section 5).

B.1 Specific Monthly QA Checks

The Quarry Operator will apply a monthly QA check to the data collected. The details of these checks will be collated and presented in the Annual Report (Section 5.1). The monthly QA checks will include:

- An assessment of the completeness of the dataset. Where data are missing, recommendation consistent with the steps described in Section 4.2 will be taken.
- An assessment of any modifications to Mitigation Measures that may be required.
- An assessment as to whether any of the information collected suggests that Contingency Measures are required (see Section 8 for a definition of what triggers Contingency Measures).

Cornelly Quarry water monitoring scheme; Record of monthly manual measurements

Date: 26th & 27th June '06

Weather at time of visit : 26th - Light rain, 27th - Dry

Weather during previous '24hrs : 25th - Dry with some rain overnight

Operative: J.Linton

Date	Time	Reference	Location Description	Water Level (m below datum):	Additional Notes		Comments			
26/06/2006	11:30	**95/01**	Cornelly (Airfield)	38.29	Level reported by logger:	38.419	Logger downloaded:	OK	Battery:	99.05%
26/06/2006	11:25	**CR96/11**	Cornelly (Airfield)	63.38						
		95/04	Cornelly (Stormy)				Submerged			
26/06/2006	09:15	**RWC100**	Grove	21.15	Level reported by logger:	21.123	Logger downloaded:	OK	Battery:	94.12%
26/06/2006	16:05	**A(1)**	50mm Blue Pipe	15.48						
		A(2)	20mm Black Pipe	14.11						
26/06/2006	16:10	**B(1)**	50mm Blue Pipe	23.1						
		B(2)	20mm Black Pipe	2.38						
26/06/2006	15:55	**C**		29.78						
26/06/2006	15:45	**D**		16.37						
26/06/2006	14:25	**G**		15.76	Note any ground water across field?		None			
26/06/2006	14:05	**H**		33.78	Level reported by logger :	33.801	Logger downloaded:	OK	Battery:	65.58%
26/06/2006	14:55	**I**		Below	Blockage at 4.7m					
26/06/2006	14:50	**L**		1.45						
27/06/2006	12:10	**K1 50mm**		2.28						

		K1 25mm		0.57		
27/06/2006	11:45	**K2 50mm**		1.79		
		K2 25mm		1.65		
27/06/2006	11:45	**K3**		4.01		
27/06/2006	11:55	**N1 50mm**		4.01		
		N2 25mm		4.02		
		N3		3.99		
27/06/2006	14:00	**36(A)**	50mm Blue Pipe	16.13	Note Last Pumping Period	Last used 25/06/2006
		36(B)	20mm Black Pipe	Dry		
27/06/2006	10:05	**17**	Pond	0.1	Gauge Board	
27/06/2006	10:00	**17b**	Private Well	34.34		
26/06/2006	15:30	**20**	Pond	1.625		
26/06/2006	15:25	**23**	Pond	1.10		
26/06/2006	14:30	**34**	Pond	0	Gauge Board	
26/06/2006	14:35	**35**	Pond	Dry	Gauge Board	
26/06/2006	15:40	**40**	Well	17.77		Alternate borehole
26/06/2006	11:05	**Cornelly Pond**	Settlement Pond	4.28	Dipped from top of Gauge board support	
26/06/2006	09:25	**Grove Sump**	Pond	0.48	Dipped from top of Gauge board support	
		Pant Mawr	Pond	H&S Access Issues	Dipped from top of Gauge board support	
		Stormy Down	Pond	H&S Access Issues		

Appendix C Assessment Criteria

C.1 Trigger Levels

Trigger Level Assessment Criteria have been defined for all for water level monitoring sites for which the development of Climate Based Assessment Criteria are not judged to be appropriate.

The Trigger Level Assessment Criteria set out in Table C.1 have been defined based on the minimum water level recorded at these sites in 2005 (a period of low groundwater level). Note that this excludes sites for which there was insufficient data in 2005 or for sites defined as Source monitoring points.

Table C.1 Trigger Levels Based on Summer 2005 Levels

ID	Trigger Level (mAOD)	Comment
17a	48.7	Pond
20	2.9	Pond
21	5.1	Tidal fluctuations.
23	3.7	Pond
34	65.2	Well dries up each year
61		No monitoring to date
A-b	-	Perched – dries up each summer
B-b		Perched – for info only
H	3.31	Tidal fluctuations.
T_95/04		Stormy Down sump – currently submerged and no recent data
K4		New borehole – baseline being established

C.2 Climate Based Assessment Criteria

The Climate Based Assessment Criteria for the remaining water level monitoring sites are illustrated in the following sheets and comments on the CBAC models are provided in Table C.2.

Table C.2 Climate Based Assessment Criteria

Site	Comment
17-b	Abstraction borehole –some local effects
A-a	
B-a	
C	
CC_5	
CC_9	
D	
D4	
D7	
D8	
G	
I	
K1a	
K1b	
K2a	
K2b	
KP	More complex model applied to allow for runoff into pond and overtopping
L	

Site	Comment
N-a	All three piezos at this site respond similarly
T_95/01	Possible drawdown trends over 2004-7?
T_96/11	Possible drawdown trends over 2004-7?

C.3 Assessment Criteria for Flow Sites

As discussed in Section 6.7.3, there is currently insufficient data available from the stream flow monitoring sites to allow reasonable Trigger Level of Climate Based Assessment Criteria to be developed. For these sites, Deviations will in the short term be assessed by reference to the Assessment Criteria of nearby water level monitoring sites as set out in Section 6.7.3.

Appendix C
Summary ofCurrent Status of Assessment Criteria

ID	Name	Monitored for quarry (mentioned in App. A) Cornelly	Grove	Gaens	CBAC?	Trigger Lavel? (mAOD)	More data needed?
14	Royal Porthcawl Golf Club		Yes	Yes			Yes
17a	Ty Tanglwyst Farm	Yes	Yes	Yes		48.7	
17b	Well	Yes	Yes	Yes	Yes		
18b	Ty Talbot Farm		Yes				Yes
20	Wilderness	Yes				2.9	
21	White Wheat	Yes				5.1	
23	Pwll y Waun	Yes				3.7	
34	Pond	Yes				65.2	
36	Royal Porthcawl Golf Club						Yes
40	Grove Golf Club		Yes	Yes	Yes		
61	Tynycaeau	Yes					Yes
65	Kenfig Golf Club						Yes
A-a		Yes	Yes	Yes	Yes		
A-b		Yes	Yes	Yes			Yes
B-a		Yes	Yes	Yes	Yes		
B-b							Yes
C (new)		Yes	Yes	Yes	Yes		
CP	Cornelly Pond/GB	Yes					Yes
CS	Cornelly Sump	Yes					Yes
D (new)		Yes	Yes	Yes	Yes		
E				Yes			Yes
G		Yes			Yes		
GAS	Gaens Sump			Yes			Yes
GRS	Grove Sump		Yes				Yes
H		Yes	Yes	Yes		3.31	
K1a	Borehole	Yes	Yes	Yes	Yes		
K1b		Yes	Yes	Yes	Yes		
K2a	Borehole	Yes	Yes	Yes	Yes		
K2b		Yes	Yes	Yes	Yes		
L		Yes			Yes		
Na	Well	Yes			Yes		
O			Yes	Yes	Yes		
P			Yes	Yes	Yes		
PM	Pant Mawr	Yes	Yes	Yes			yes
Q				Yes	Yes		
R			Yes	Yes	Yes		
RWC100			Yes		Yes (Not used anymore)		
RWC105			Yes		Yes		
RWC106			Yes		Yes		
S		yes					
T	Newton	Yes					Yes
T_95/01	Airfield	Yes			Yes		
T_95/04	Stormy Down Quarry	Yes					Yes
U		Yes			Yes		
Raingauge		Yes	Yes	Yes			Yes
							Yes
HL11	Stormy Spring	Yes		Yes			Yes
HL13	spring in valley by dunes	Yes					Yes
HL14	by dunes carpark	Yes					Yes
HL15	Burrows well	Yes			Yes		
HL6		Yes	Yes	Yes			Yes
HL9A1	u/s New Mill springs		Yes	Yes			Yes
HL9B	d/s New Mill Springs		Yes	Yes			Yes
CS	Cornelly sump	Yes					Yes
GAS	Grove sump		Yes				Yes
GRS	Gaens sump			Yes			Yes
							Yes
Third Party							
CC_5					Yes		
CC_9					Yes		
D4					Yes		
D7					Yes		
D8					Yes		
KP							Yes

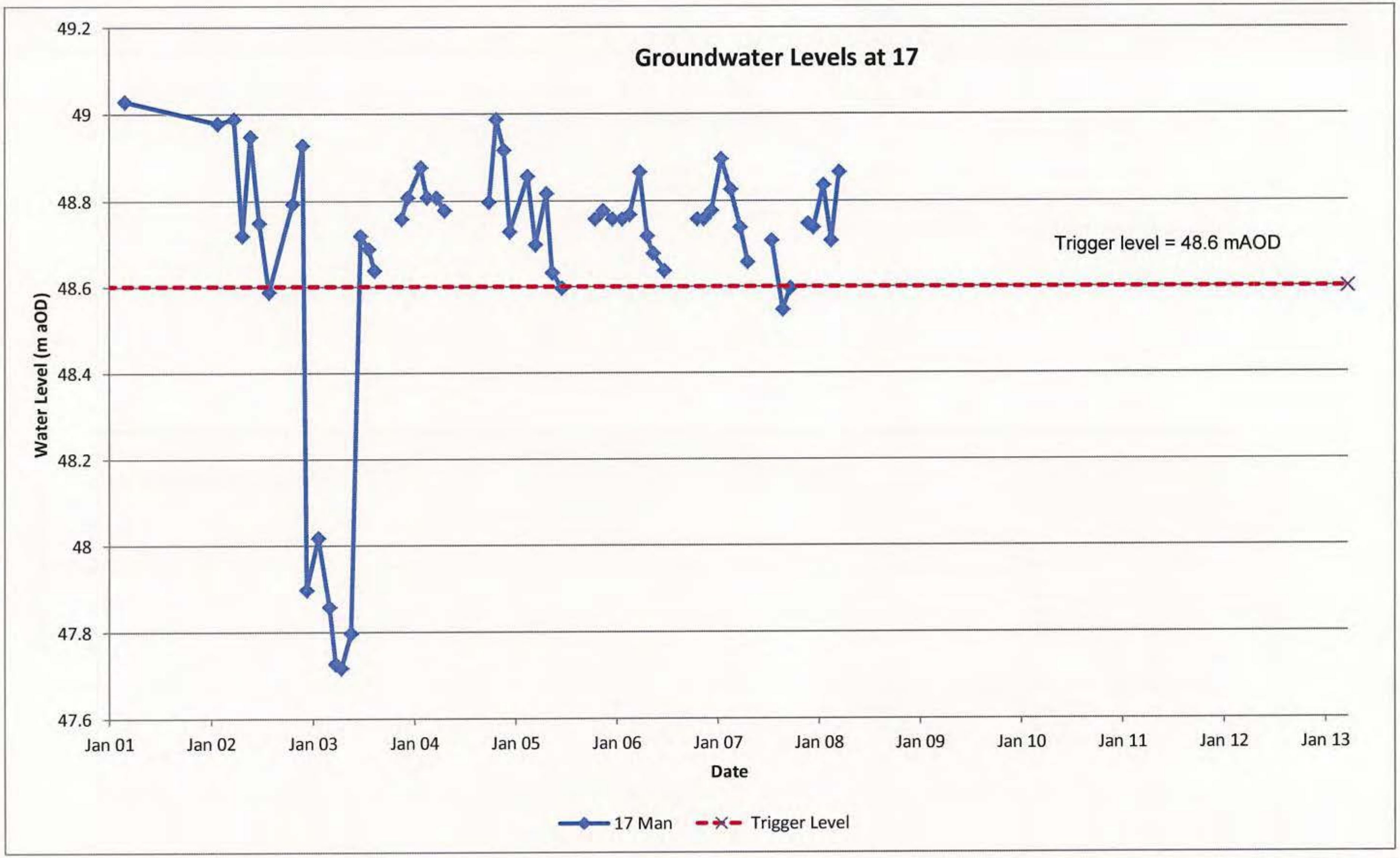


Figure H.1

Groundwater levels at 17 (north of Cornelly Quarry) and trigger level

Date	Drawn
Aug-13	HJK
Scale dns	Checked AWT
Original A4	Revision 1
File Reference O:\6227_Cornelly\data\monitoring\water level reports\11 2013\H.3.xls	

esi Environment Specialists

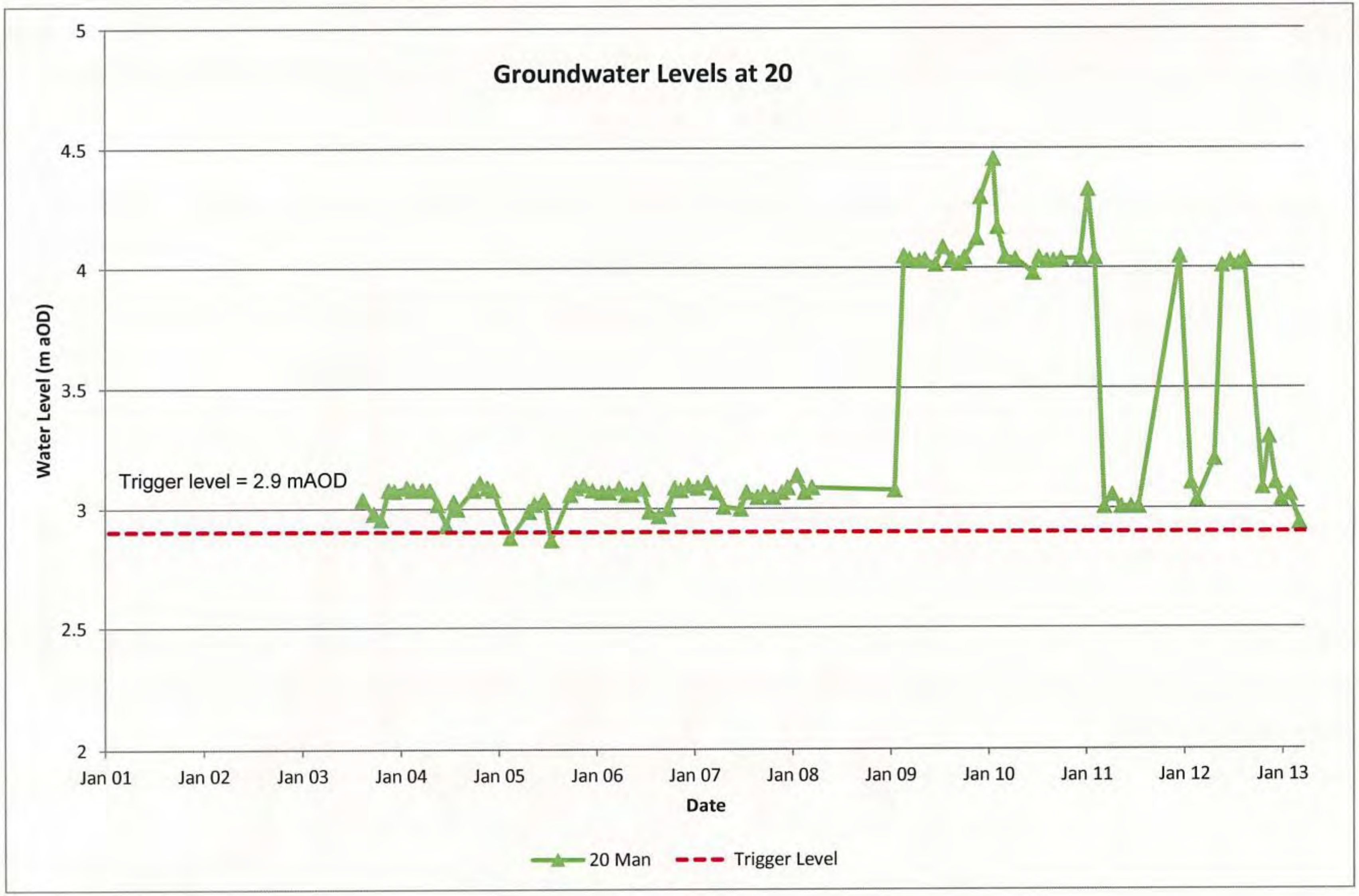


Figure H.2

Groundwater levels at 20 (Porth Cawl) and trigger level

Date	Drawn
Aug-13	HJK
Scale	Checked
dns	AWT
Original	Revision
A4	1

File Reference

O:\6227_Cornelly\data\monitoring\water level reports\11 2013\D.21.xls

esi Environment Specialists

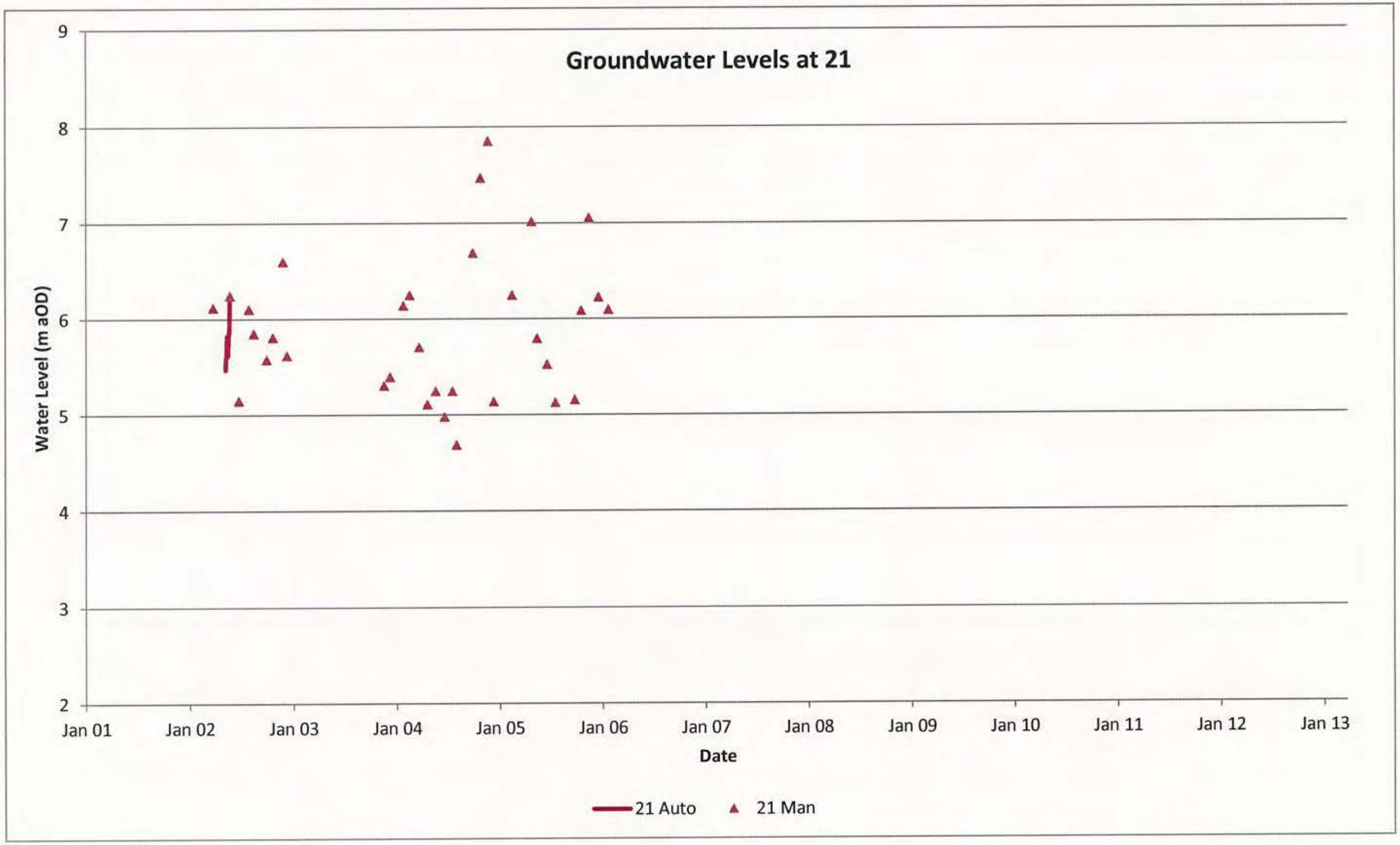


Figure H.3

Groundwater levels at 21 (Porth Cawl)

Date Aug-13	Drawn HJK
Scale dns	Checked AWT
Original A4	Revision 1
File Reference O:\6227_Cornelly\data\monitoring\water level reports\11 2013\H.5.xls	

esi Environment Specialists

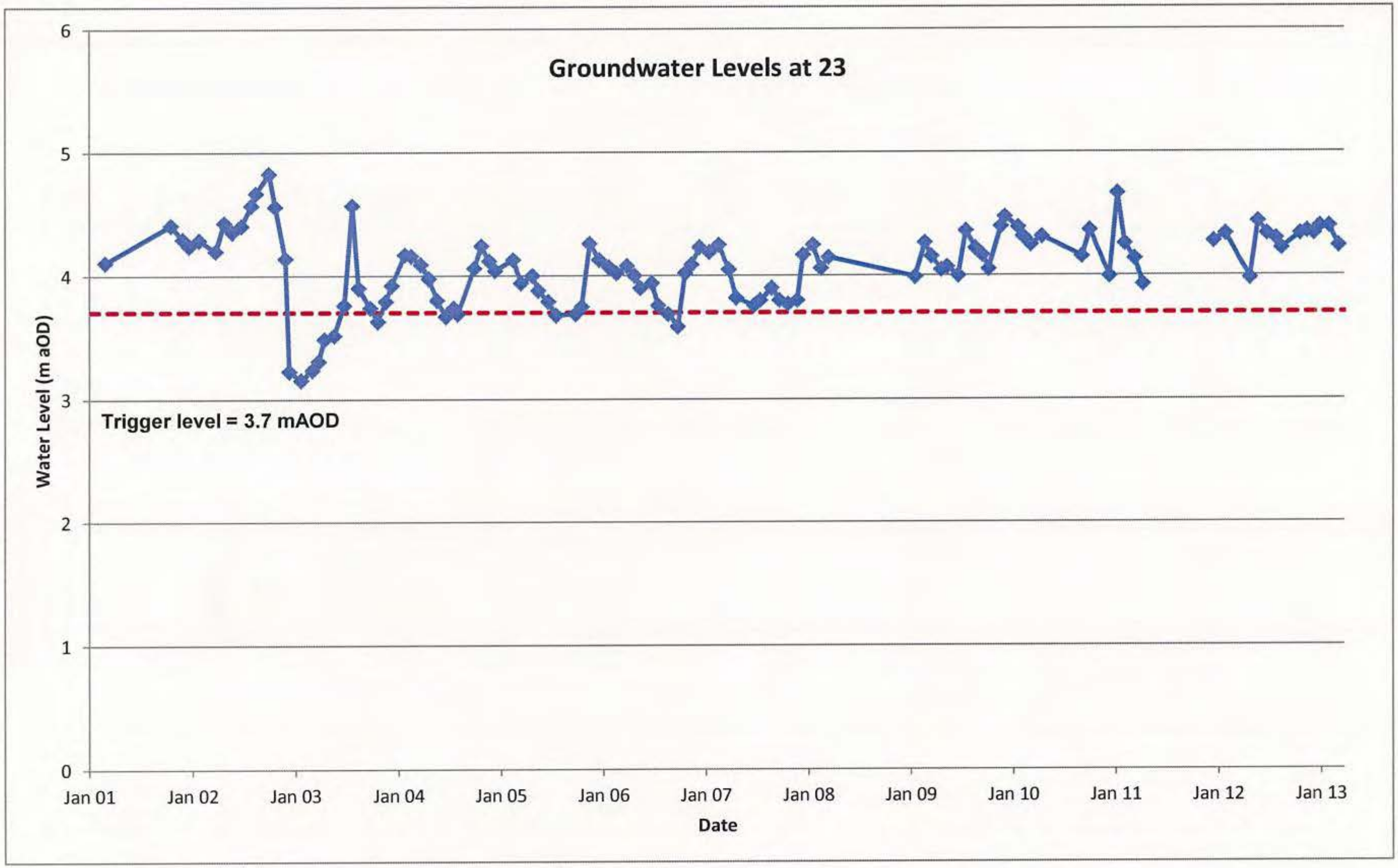


Figure H.4

Groundwater levels at 23 (Porth Cawl) and trigger level

Date	Drawn
Aug-13	HJK
Scale	Checked
dns	AWT
Original	Revision
A4	1

File Reference

O:\6227_Cornelly\data\monitoring\water level reports\11 2013\H.6.xls

Enviro
Spec

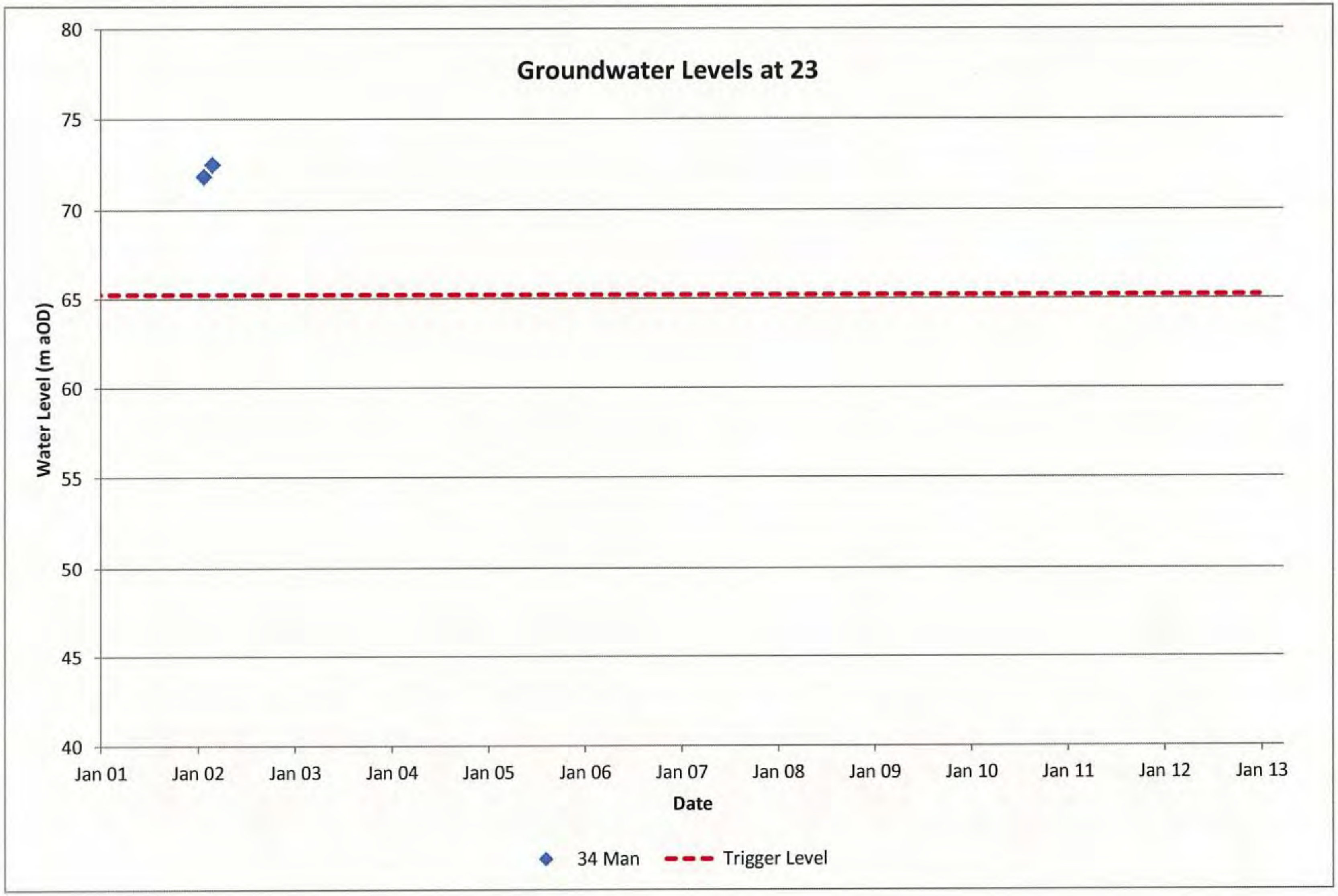


Figure H.5

Groundwater levels at 34 (Tythegston landfill) and trigger level

Date Aug-13	Drawn HJK
Scale dns	Checked AWT
Original A4	Revision 1
File Reference O:\6227_Cornelly\data\monitoring\water level reports\11 2013\H.7.xls	

esi Environment Specialists

Figure H.8

Groundwater levels at A-b (Kenfig Pool)

Date	Drawn
Aug-13	HJk
Scale	Checked
dns	AWT
Original	Revision
A4	1

File Reference
O:\6227_Cornelly\data\monitoring\water level reports\11 2013\[H.8.xlsx]Report_ready

esi Environment Specialists

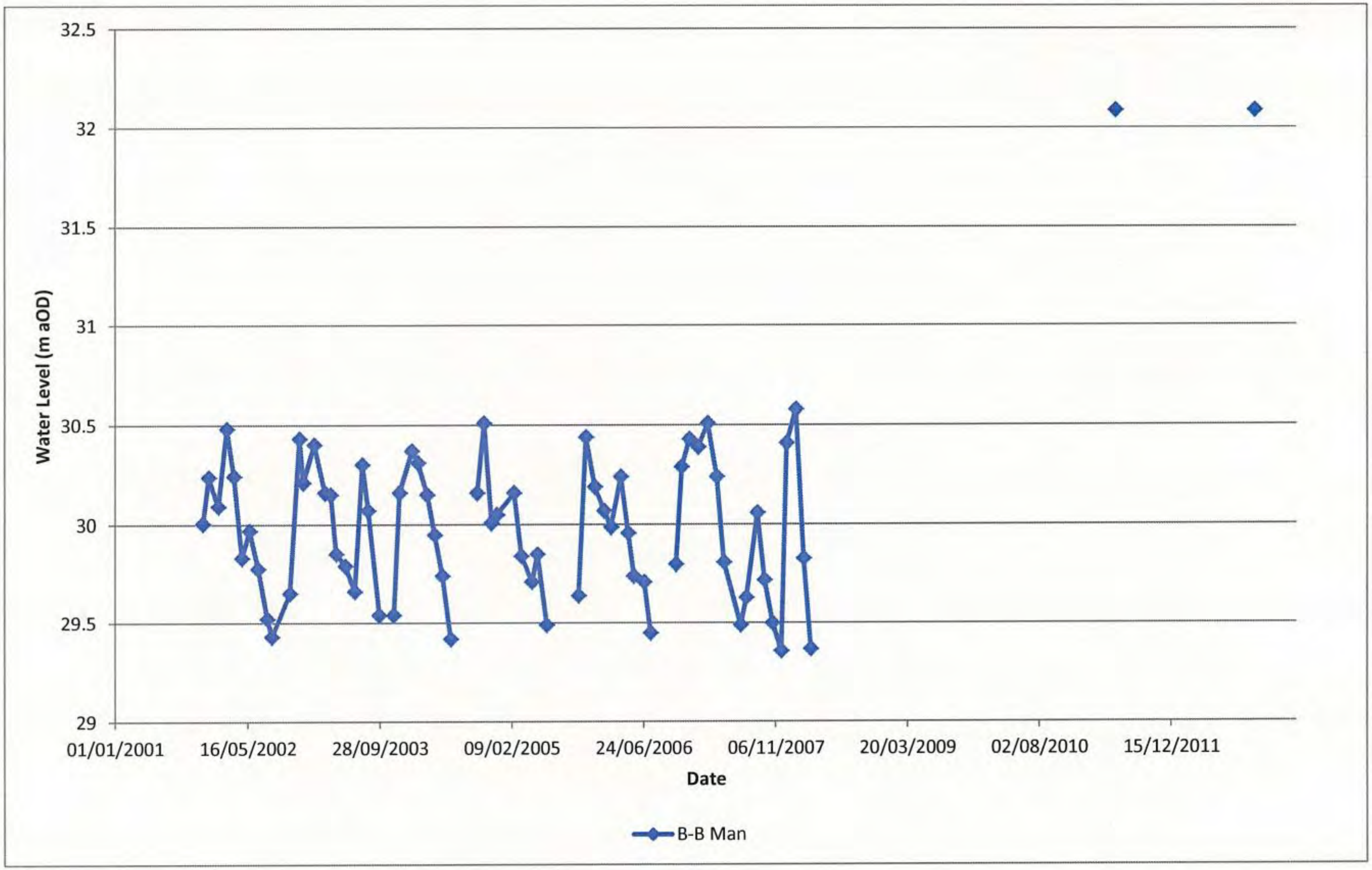


Figure H.7

Groundwater levels at B-b (Sker)

Date	Drawn
Aug-13	HJK
Scale	Checked
dns	AWT
Original	Revision
A4	1
File Reference	
O:\6227_Cornelly\data\monitoring\water level reports\11 2013\H.9.xls	

esi Environment Specialists

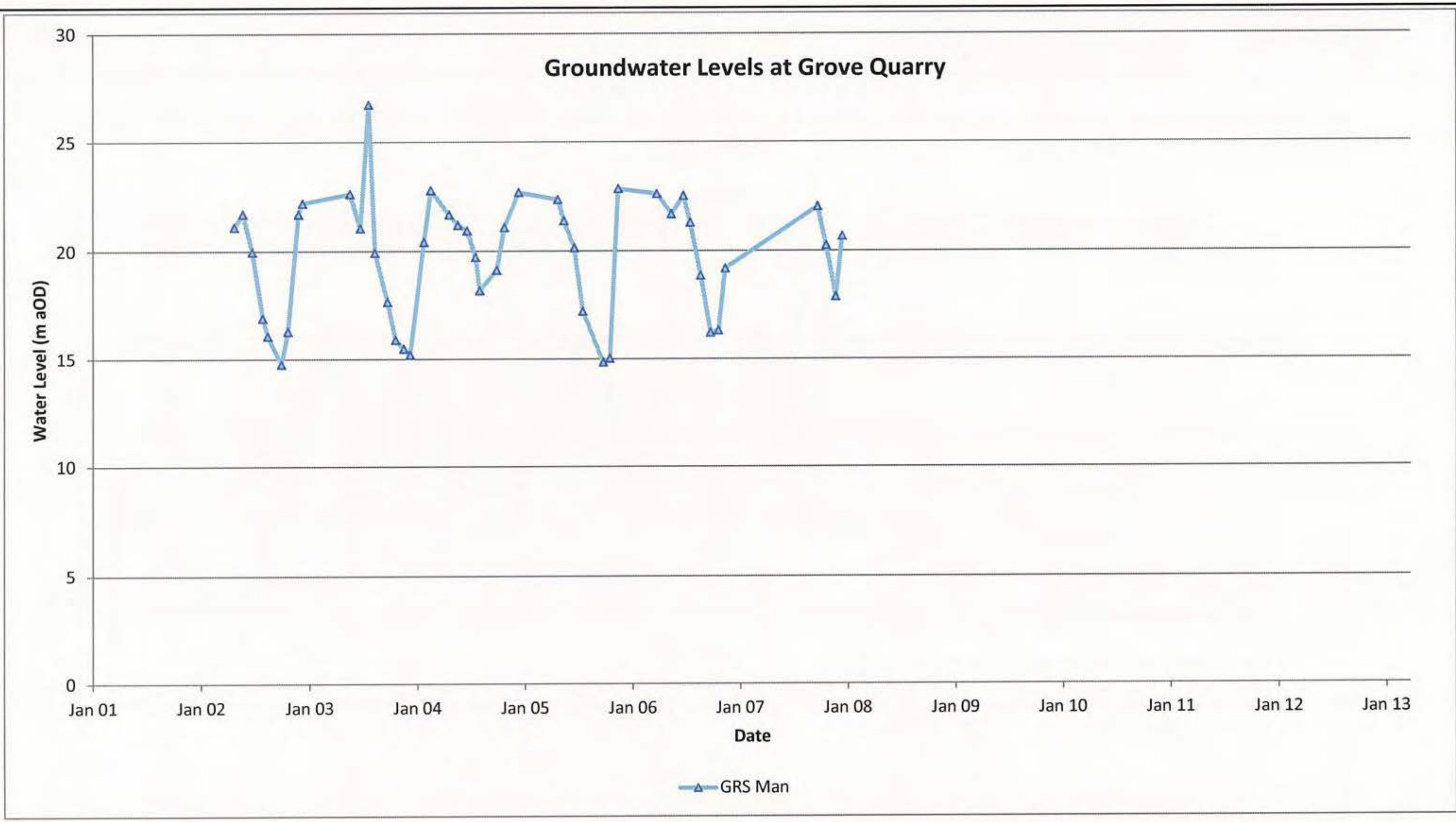


Figure H.8
Groundwater levels at GRS (Grove Quarry)

Date: Aug 13	Drawn: HJK
Scale: dns	Checked: AWT
Original: A4	Revision: 1
File Reference: O:\6227_Cornelly\data\monitoring\water level reports\10 May 2013\H.10.xls	

esi

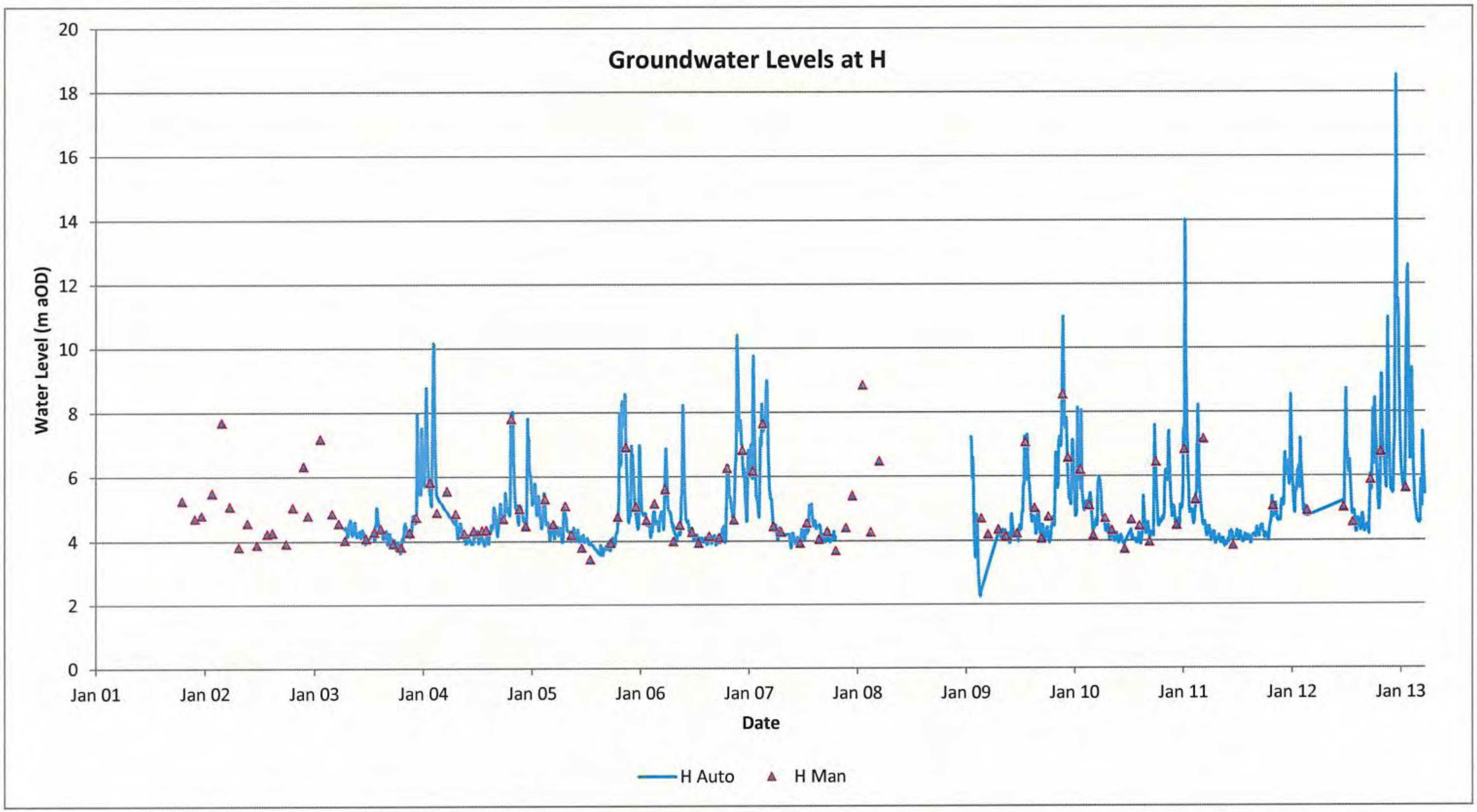


Figure H.9
Groundwater levels at H (Grove Quarry)

Date Aug 13	Drawn HJK
Scale n/a	Checked AWT
Original A4	Revision 1
File Reference O:\6227_Cornelly\data\monitoring\water level reports\11 2013\H.11.xls	

esi

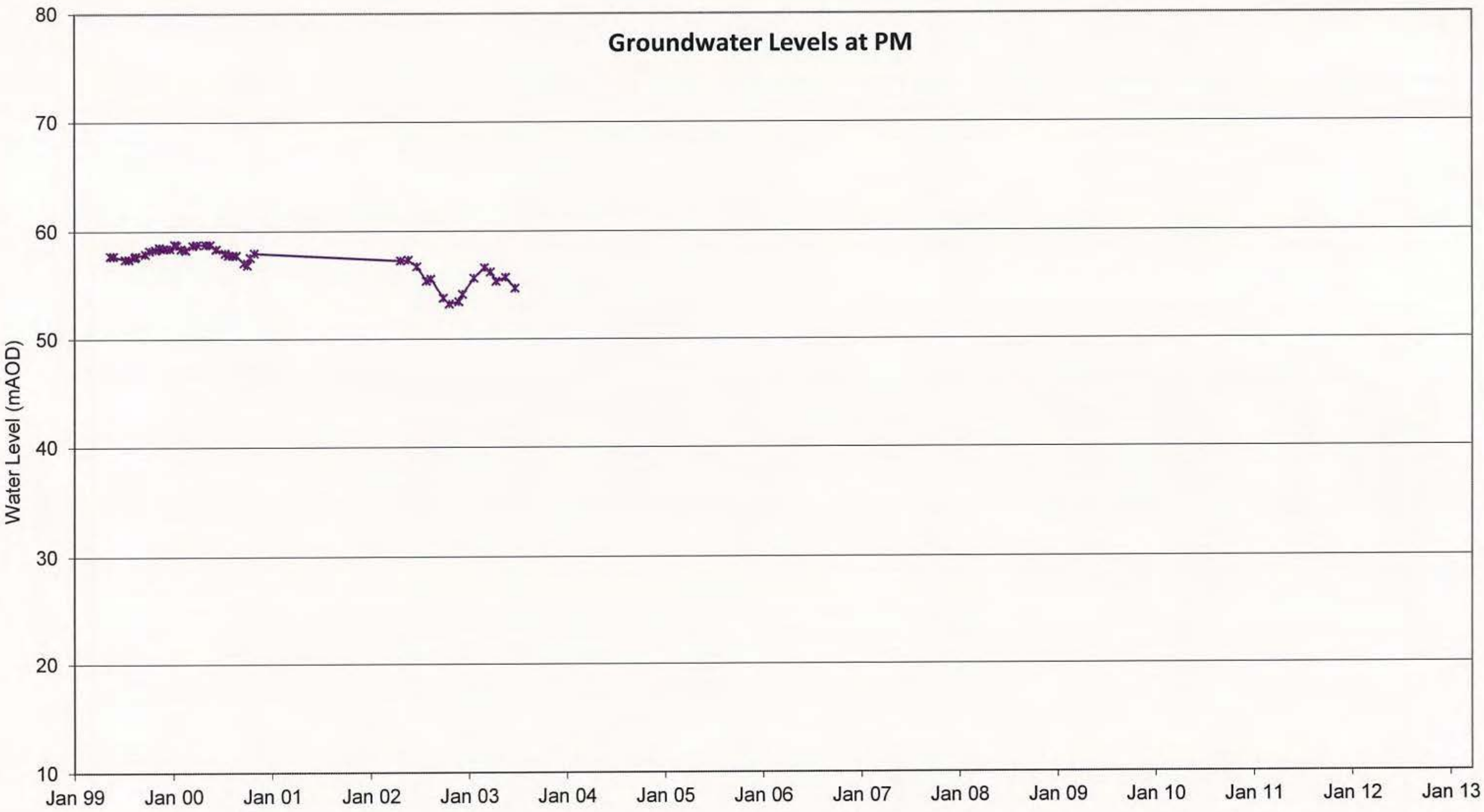


Figure H.10
Groundwater levels at PM (Cornelly Quarry)

Date	Drawn
Aug 13	HJK
Scale: dns	Checked: AWT
Original: A4	Revision: 1

File Reference
O:\6227_Cornelly\data\monitoring\water level reports\10 May 2012\May12_Cornelly.xls

esi

Runoff Calculation Parameters (Location 40)

Parameters for Soil Moisture Balance

Drying constant (mm)	Direct percolation (%)	Drying curve slope
75	25	0.3
SMD1_start (mm)	SMD2_start (mm)	
0	0	

All Parameters provided

Runoff Parameters

SMD	5	30	
0	0.01	0.035	0.275
20	0	0.01	0.025

Rainfall station: Cefn Cribwr

General parameters **Head Change Calculation**

	Catchment_Area (m2)	Specific_Yield	Starting_Head
SW	1,420,082	0.03	4
GW	1,420,082		

Rainfall Multiplier	1
PE Multiplier	1

User-defined time series

Precipitation (mm) - Sheet SMB calcs
Potential evapotranspiration (mm) - Sheet SMB calcs
Nb Change cells references on water balance sheet

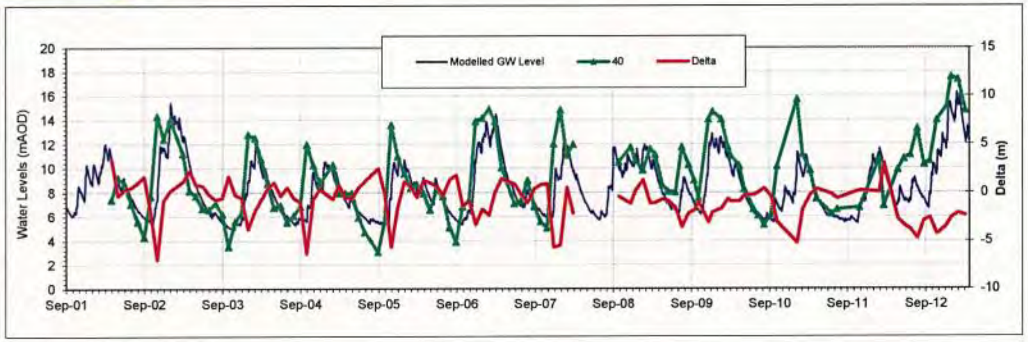
Stores Parameters

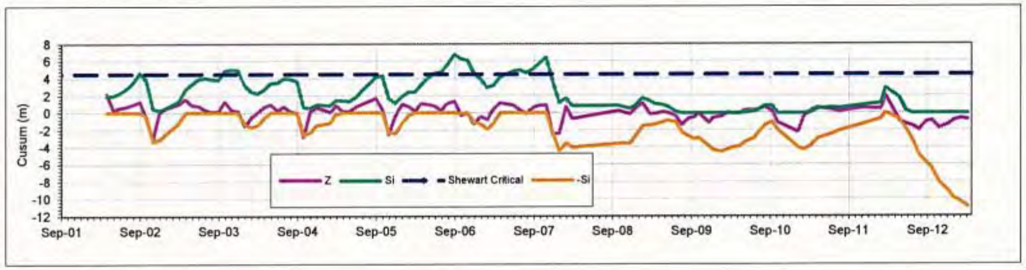
EffectiveOvertop Specific Yield	1	
Store Starting Volume	0.1	m
Overtop	16	
v_top multiplier	5	
V top	8	
T Slow	75	days
T Fast	4	days
Runoff multiplier	0	

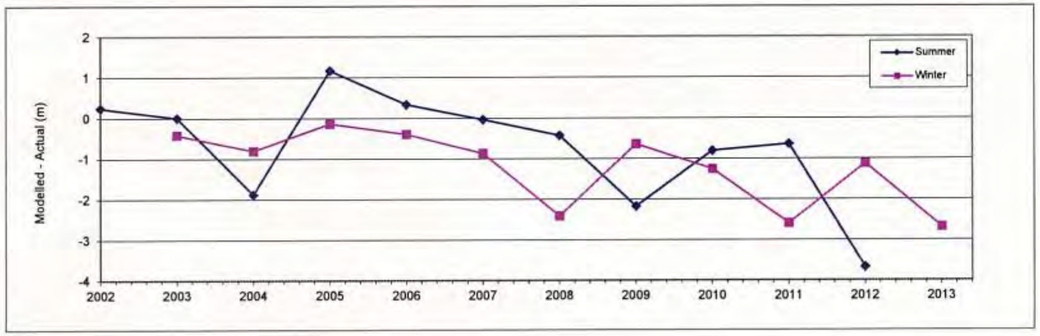
Stats

K (not permeability!!)	0.2	m
Mean Error (modelled - Actual)	-0.87	m
ST Dev Error	1.97	m
Mean summer error	-0.80	m
Max Summer error	-0.14	m
Min Summer error	-2.68	m
Dummy value for Z_i	0	

NOTE: Summer goes from July to October Included;
Winter goes from November to June the following year.







Runoff Calculation Parameters (Location Oa)

Parameters for Soil Moisture Balance

Drying constant (mm)	Direct percolation (%)	Drying curve slope
50	20	0.3
SMD1_start (mm)	SMD2_start (mm)	
0	0	

All Parameters provided

Runoff Parameters

SMD	5	30	
0	0.01	0.035	0.275
20	0	0.01	0.025

Rainfall Station: Cefn Cribwr

General parameters **Head Change Calculation**

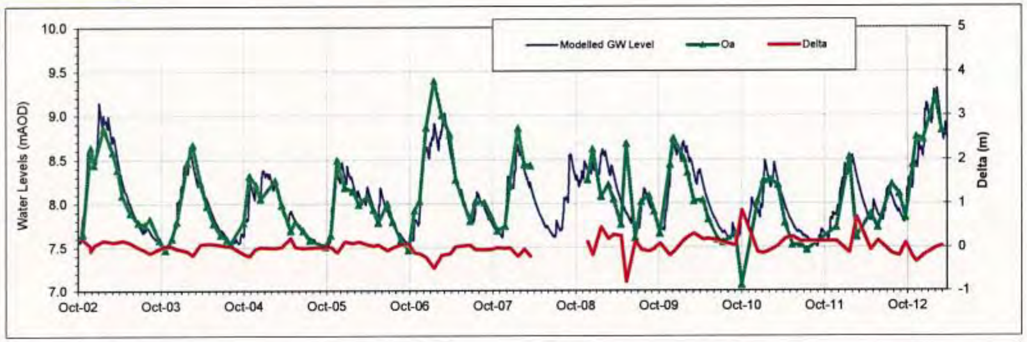
	Catchment_Area (m2)	Specific_Yield	Starting_Head
SW	1,756,799	0.2	7.3
GW	1,756,799		

Rainfall Multiplier	1
PE Multiplier	1

User-defined time series

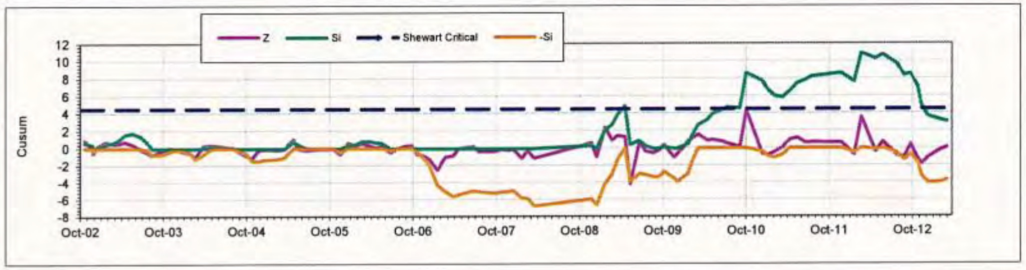
Precipitation (mm) - Sheet SMB calcs
Potential evapotranspiration (mm) - Sheet SMB calcs
Nb Change cells references on water balance sheet

Stores Parameters		
EffectiveOvertop Specific Yield	1	
Store Starting Volume	0	m
v_top multiplier	7	
Overtop	9.5	
V top	8	
T Slow	85	days
T Fast	5	days
Runoff multiplier	0	

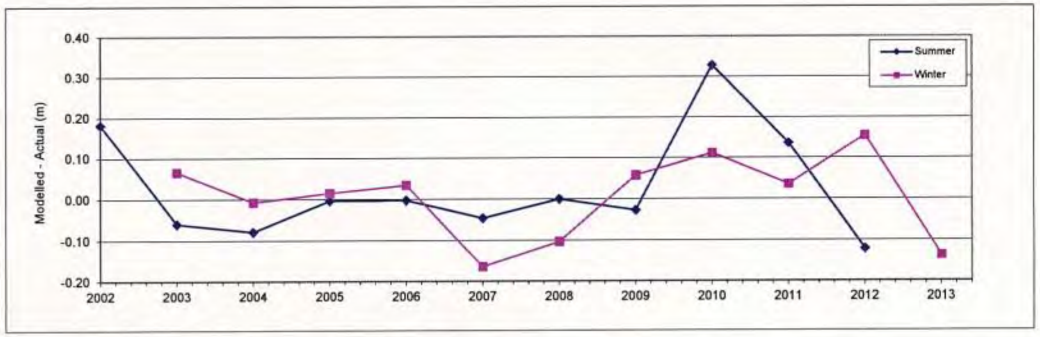


Stats

K (not permeability!!)	0.25	m
Mean Error (modelled - Actual)	0.01	m
ST Dev Error	0.19	m
Mean summer error	0.00	m
Max Summer error	0.16	m
Min Summer error	-0.16	m
Dummy value for Z_i	0	



NOTE: Summer goes from July to October Included;
Winter goes from November to June the following year.



Runoff Calculation Parameters (Location P)

Parameters for Soil Moisture Balance

Drying constant (mm)	Direct percolation (%)	Drying curve slope
75	25	0.3
SMD1_start (mm)	SMD2_start (mm)	
0	0	

All Parameters provided

Runoff Parameters

SMD	5	30	
0	0.01	0.035	0.275
20	0	0.01	0.025

Rainfall station: Cefn Cribwr

General parameters **Head Change Calculation**

	Rainfall Multiplier	1	
	PE Multiplier	1	

	Catchment_Area (m2)	Specific_Yield	Starting_Head
SW	1,420,082	0.012	10
GW	1,420,082		

User-defined time series

Precipitation (mm) - Sheet SMB calcs
Potential evapotranspiration (mm) - Sheet SMB calcs
Nb Change cells references on water balance sheet

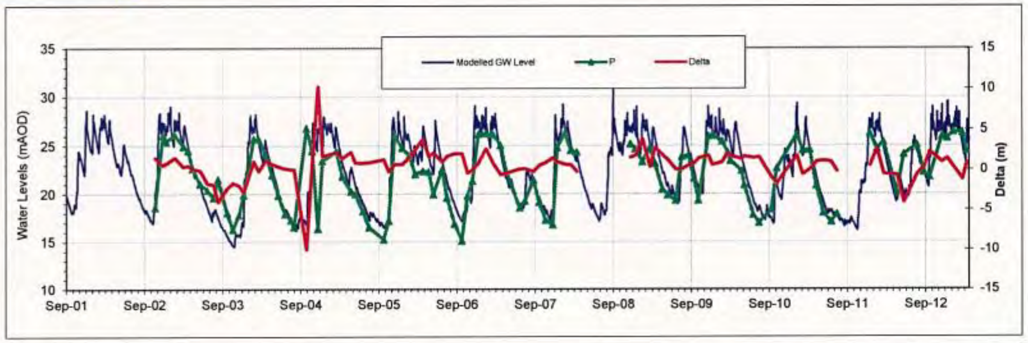
Stores Parameters

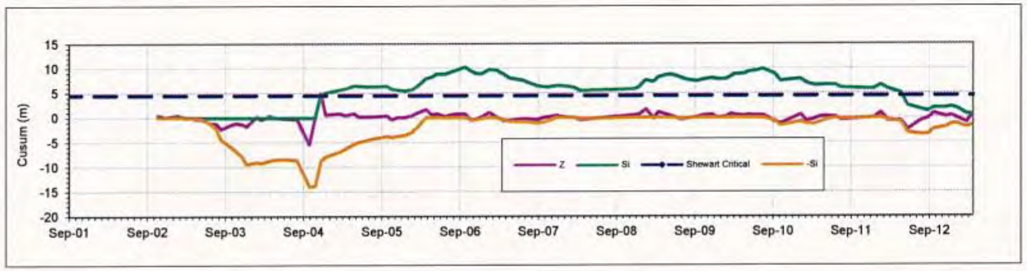
EffectiveOvertop Specific Yield	1	
Store Starting Volume	0.1	m
Overtop	27	
v_top multiplier	5	
V top	25	
T Slow	120	days
T Fast	4	days
Runoff multiplier	0	

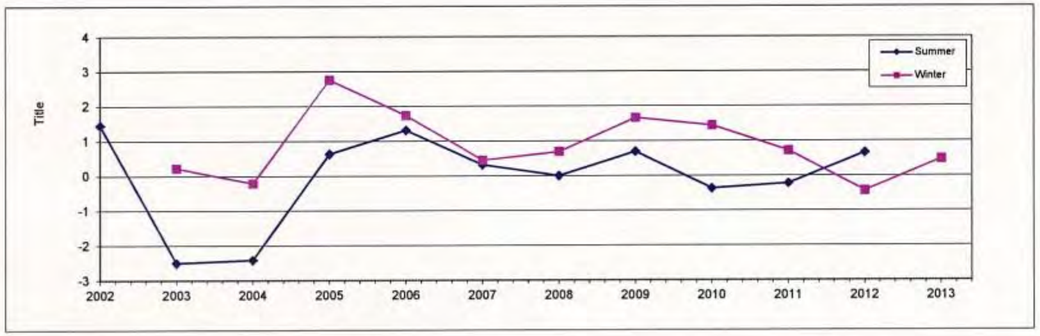
Stats

K (not permeability!!)	0.2	m
Mean Error (modelled - Actual)	0.59	m
ST Dev Error	1.95	m
Mean summer error	-0.21	m
Max Summer error	2.76	m
Min Summer error	-0.43	m
Dummy value for Z_i	0	

NOTE: Summer goes from July to October Included;
Winter goes from November to June the following year.







Runoff Calculation Parameters (Location Q)

Parameters for Soil Moisture Balance

Drying constant (mm)	Direct percolation (%)	Drying curve slope
75	25	0.3
SMD1_start (mm)	SMD2_start (mm)	
0	0	

All Parameters provided

Runoff Parameters

SMD	5	30	
0	0.01	0.035	0.275
20	0	0.01	0.025

Rainfall station: Cefn Cribwr

Rainfall Multiplier	1
PE Multiplier	1

General parameters **Head Change Calculation**

	Catchment_Area (m2)	Specific_Yield	Starting_Head
SW	1,420,082	0.01	20
GW	1,420,082		

User-defined time series

Precipitation (mm) - Sheet SMB calcs
Potential evapotranspiration (mm) - Sheet SMB calcs
Nb Change cells references on water balance sheet

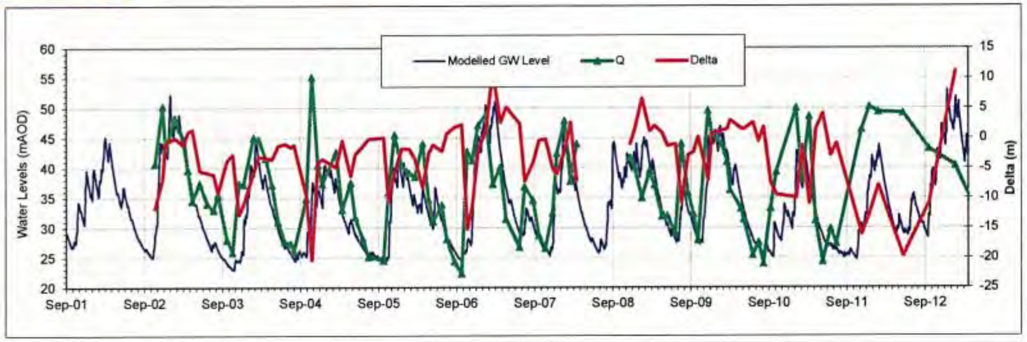
Stores Parameters

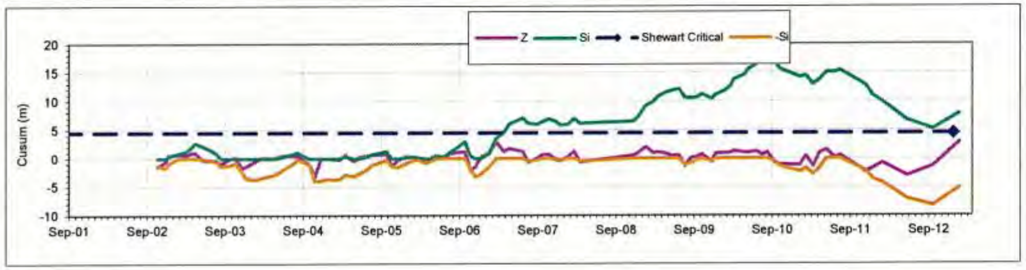
EffectiveOvertop Specific Yield	1	
Store Starting Volume	0.1	m
Overtop	50	
v_top multiplier	5	
V top	25	
T Slow	80	days
T Fast	8	days
Runoff multiplier	0	

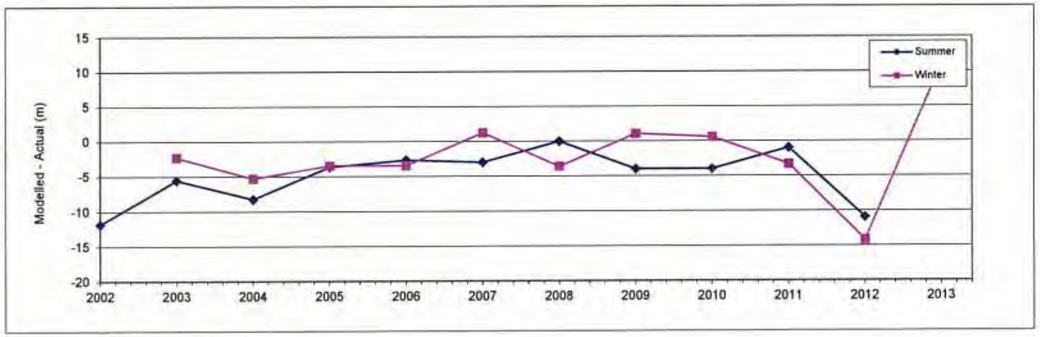
Stats

K (not permeability!!)	0.2	m
Mean Error (modelled - Actual)	-3.85	m
ST Dev Error	5.20	m
Mean summer error	-4.80	m
Max Summer error	11.09	m
Min Summer error	-14.12	m
Dummy value for Z_i	0	

NOTE: Summer goes from July to October Included;
Winter goes from November to June the following year.







Runoff Calculation Parameters (Location RWC105)

Parameters for Soil Moisture Balance

Drying constant (mm)	Direct percolation (%)	Drying curve slope
75	25	0.3
SMD1_start (mm)	SMD2_start (mm)	
0	0	

All Parameters provided

Runoff Parameters

SMD	5	30	
0	0.01	0.035	0.275
20	0	0.01	0.025

Rainfall station: Cefn Cribwr

General parameters **Head Change Calculation**

Rainfall Multiplier 1
PE Multiplier 1

	Catchment_Area (m2)	Specific_Yield	Starting_Head
SW	1,420,082	0.015	9
GW	1,420,082		

User-defined time series

Precipitation (mm) - Sheet SMB calcs
Potential evapotranspiration (mm) - Sheet SMB calcs
Nb Change cells references on water balance sheet

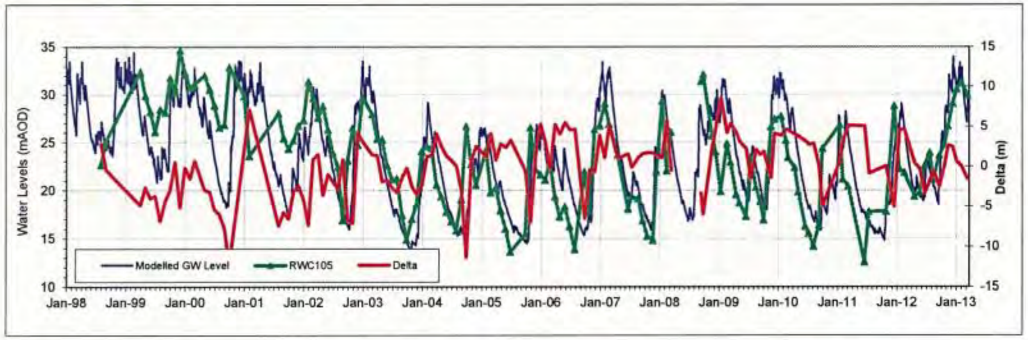
Stores Parameters

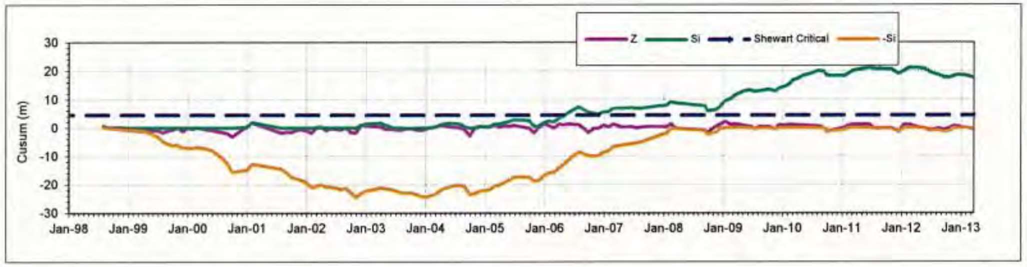
EffectiveOvertop Specific Yield	1	
Store Starting Volume	0.1	m
Overtop	32	
v_top multiplier	5	
V top	30	
T Slow	120	days
T Fast	4	days
Runoff multiplier	0	

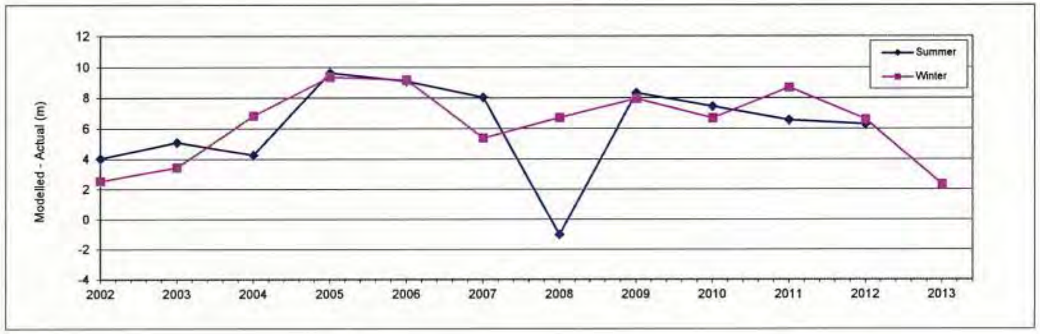
Stats

K (not permeability!!)	0.2	m
Mean Error (modelled - Actual)	-0.02	m
ST Dev Error	3.83	m
Mean summer error	4.80	m
Max Summer error	9.37	m
Min Summer error	-0.56	m
Dummy value for Z_i	0	

NOTE: Summer goes from July to October Included;
Winter goes from November to June the following year.







Runoff Calculation Parameters (Location RWC106)

Parameters for Soil Moisture Balance

Drying constant (mm)	Direct percolation (%)	Drying curve slope
75	25	0.3
SMD1_start (mm)	SMD2_start (mm)	
0	0	

All Parameters provided

Runoff Parameters

SMD	5	30	
0	0.01	0.035	0.275
20	0	0.01	0.025

Rainfall station: Cefn Cribwr

General parameters **Head Change Calculation**

	Catchment_Area (m2)	Specific_Yield	Starting_Head
SW	1,420,082	0.015	9
GW	1,420,082		

Rainfall Multiplier	1
PE Multiplier	1

User-defined time series

Precipitation (mm) - Sheet SMB calcs
Potential evapotranspiration (mm) - Sheet SMB calcs
Nb Change cells references on water balance sheet

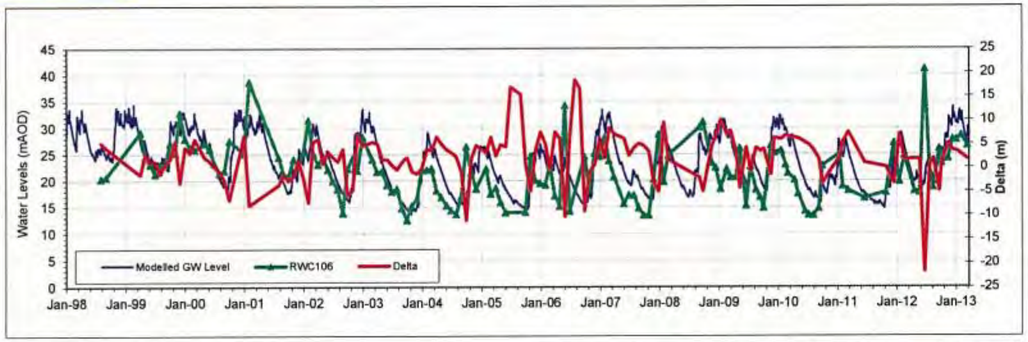
Stores Parameters

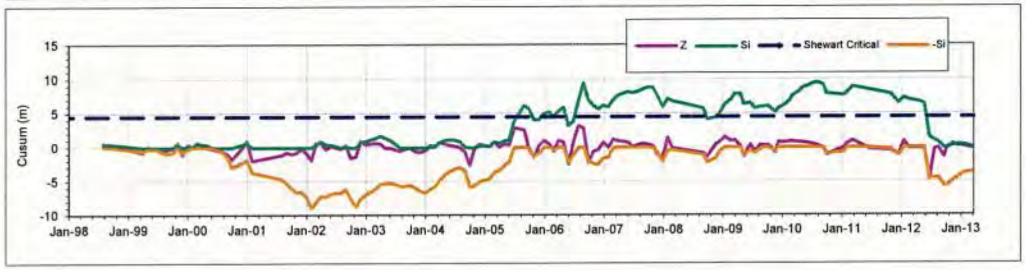
EffectiveOvertop Specific Yield	1	
Store Starting Volume	0.1	m
Overtop	32	
v_top multiplier	5	
V top	30	
T Slow	120	days
T Fast	4	days
Runoff multiplier	0	

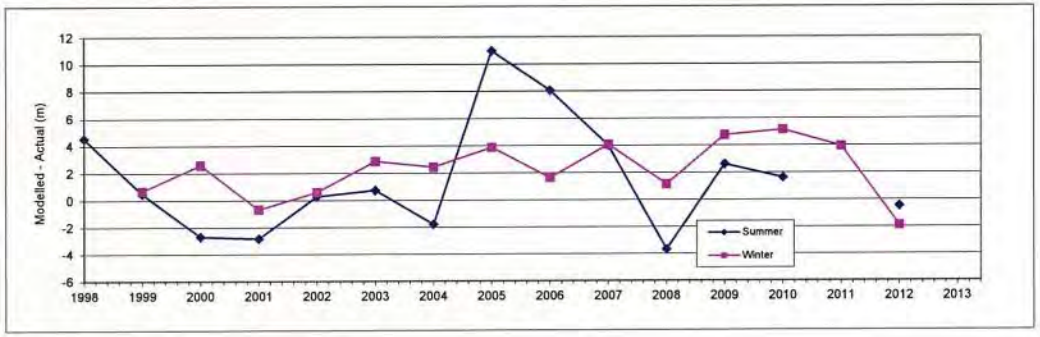
Stats

K (not permeability!!)	0.2	m
Mean Error (modelled - Actual)	2.19	m
ST Dev Error	5.15	m
Mean summer error	1.56	m
Max Summer error	5.17	m
Min Summer error	-1.87	m
Dummy value for Z_i	0	

NOTE: Summer goes from July to October Included;
Winter goes from November to June the following year.







Runoff Calculation Parameters (Location South Cornelly)

Parameters for Soil Moisture Balance

Drying constant (mm)	Direct percolation (%)	Drying curve slope
75	15	0.3
SMD1_start (mm)	SMD2_start (mm)	
0	0	

All Parameters provided

Runoff Parameters

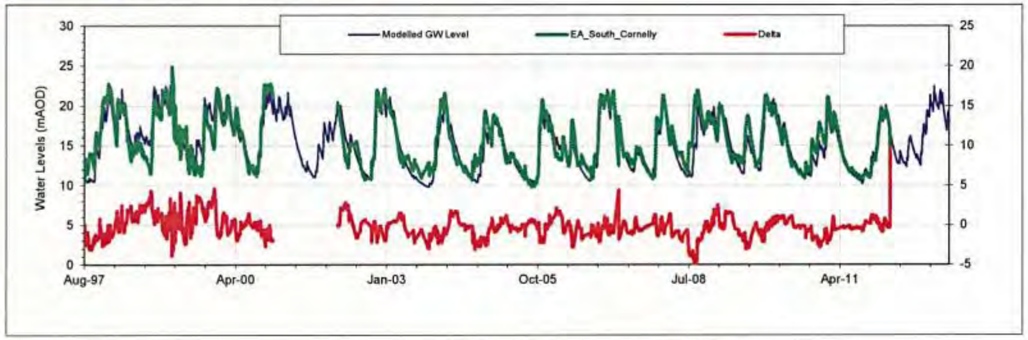
SMD	5	30	
0	0.01	0.035	0.275
20	0	0.01	0.25

Rainfall station: Cefn Cribwr

Rainfall Multiplier	1
PE Multiplier	1

General parameters **Head Change Calculation**

	Catchment_Area (m2)	Specific_Yield	Starting_Head
SW	1,756,799	0.02	9.1
GW	1,756,799		



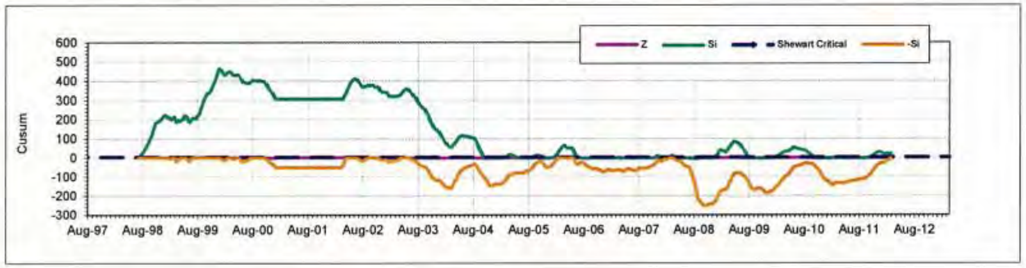
User-defined time series

Precipitation (mm) - Sheet SMB calcs
Potential evapotranspiration (mm) - Sheet SMB calcs
Nb Change cells references on water balance sheet

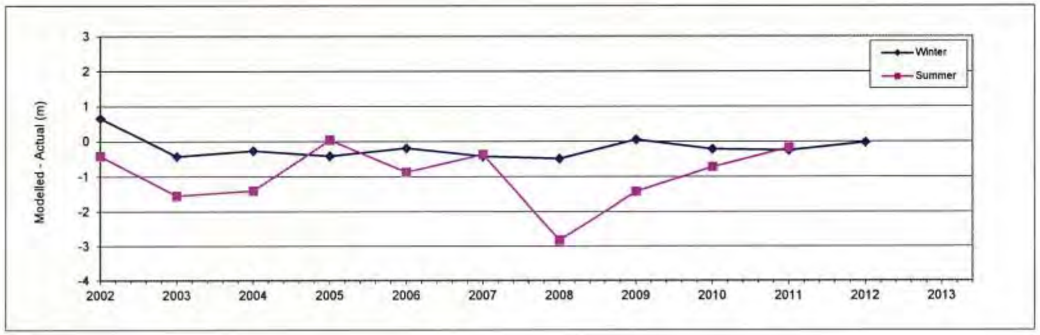
Stores Parameters		
EffectiveOvertop Specific Yield	1	
Store Starting Volume	0	m
v_top multiplier	7	
Overtop	21	
V top	18	
T Slow	70	days
T Fast	4	days
Runoff multiplier	0	

Stats

K (not permeability!!)	0.25	m
Mean Error (modelled - Actual)	-0.27	m
ST Dev Error	1.35	m
Mean summer error	-0.48	m
Max Summer error	2.12	m
Min Summer error	-2.83	m
Dummy value for Z_i	0	



NOTE: Summer goes from July to October Included;
Winter goes from November to June the following year.



Runoff Calculation Parameters (CC 5)

Parameters for Soil Moisture Balance

Drying constant (mm)	Direct percolation (%)	Drying curve slope
75	25	0.3
SMD1_start (mm)	SMD2_start (mm)	
0	0	

All Parameters provided

Runoff Parameters

SMD	5	30	
0	0.01	0.035	0.275
20	0	0.01	0.025

Rainfall station: Kenfig

General parameters **Head Change Calculation**

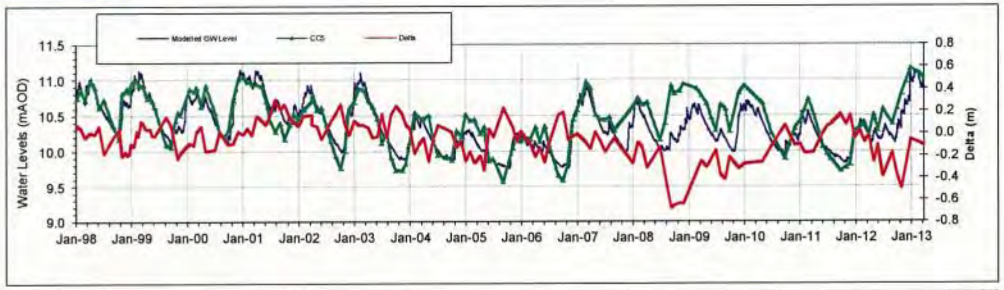
	Catchment_Area (m2)	Specific_Yield	Starting_Head
SW	3,560,000	0.3	9.3
GW	3,560,000		

Rainfall Multiplier	1
PE Multiplier	1

User-defined time series

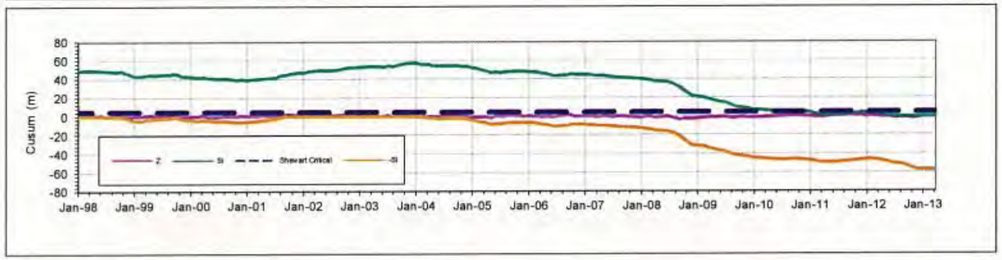
Precipitation (mm) - Sheet SMB calcs
Potential evapotranspiration (mm) - Sheet SMB calcs
Nb Change cells references on water balance sheet

Stores Parameters		
EffectiveOvertop Specific Yiel	1	
Store Starting Volume	0.45	m
Overtop	11.1	mAOD
T Slow	180	days
T Fast	4	days
Runoff multiplier	0	

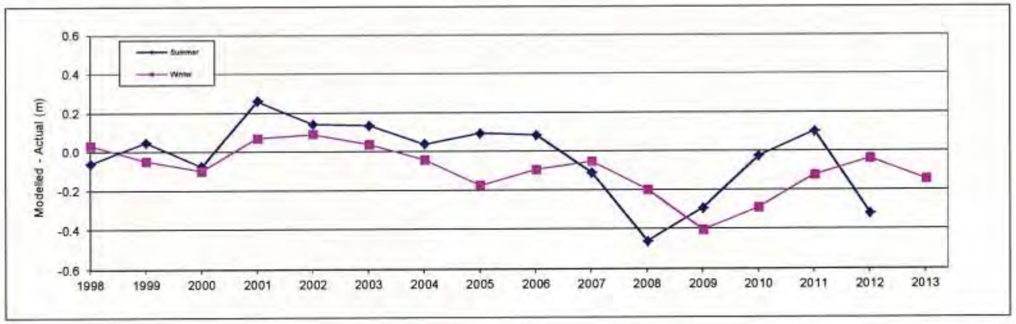


Stats

K (not permeability!!)	0.05	m
Mean Error (modelled - Actual	-0.01	m
ST Dev Error	0.20	m
Mean summer error	0.03	m
Max Summer error	0.52	m
Min Summer error	-0.17	m
Dummy value for Z_i	0	



NOTE: Summer goes from July to October Included;
Winter goes from November to June the following year.



Runoff Calculation Parameters (Location CC 9)

Parameters for Soil Moisture Balance

Drying constant (mm)	Direct percolation (%)	Drying curve slope
75	25	0.3
SMD1_start (mm)	SMD2_start (mm)	
0	0	

All Parameters provided

Runoff Parameters

SMD	5	30	
0	0.01	0.035	0.275
20	0	0.01	0.025

Rainfall station: Kenfig

General parameters **Head Change Calculation**

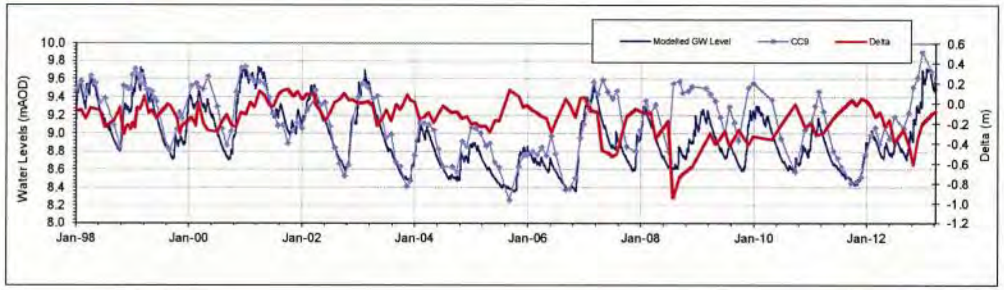
Rainfall Multiplier	1	
PE Multiplier	1	

	Catchment_Area (m2)	Specific_Yield	Starting_Head
SW	3,560,000	0.3	7.9
GW	3,560,000		

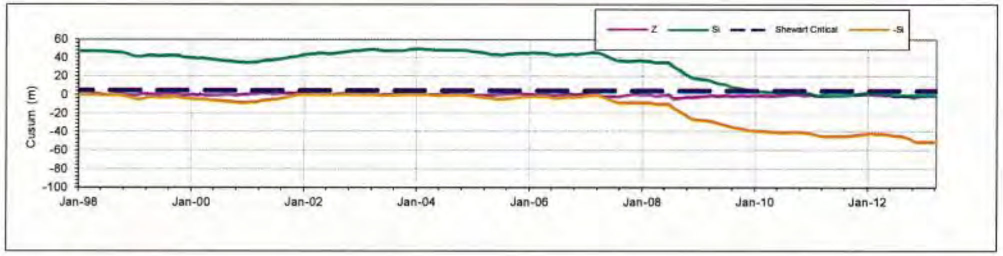
User-defined time series

Precipitation (mm) - Sheet SMB calcs
Potential evapotranspiration (mm) - Sheet SMB calcs
Nb Change cells references on water balance sheet

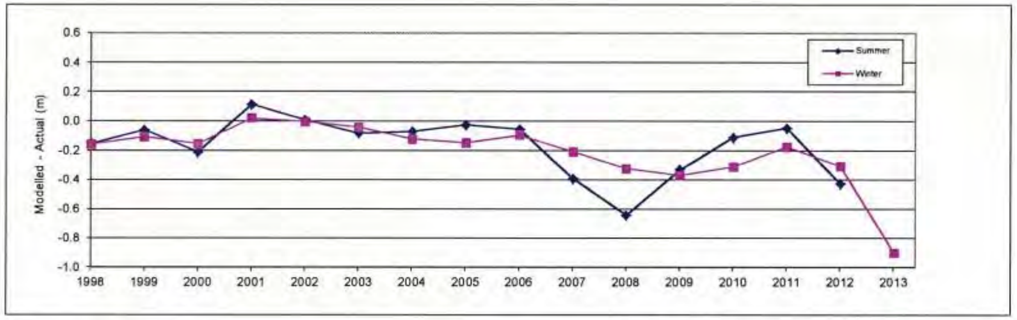
Stores Parameters		
EffectiveOvertop Specific Yiel	1	
Store Starting Volume	0.45	m
Overtop	9.7	mAOD
T Slow	180	days
T Fast	4	days
Runoff multiplier	0	



Stats		
K (not permeability!!)	0.05	m
Mean Error (modelled - Actua	-0.09	m
ST Dev Error	0.20	m
Mean summer error	-0.10	m
Max Summer error	0.46	m
Min Summer error	-0.23	m
Dummy value for Z_i	0	



NOTE: Summer goes from July to October Included; Winter goes from November to June the following year.



Runoff Calculation Parameters (Location K1a)

Parameters for Soil Moisture Balance

Drying constant (mm)	Direct percolation (%)	Drying curve slope
75	10	0.3
SMD1_start (mm)	SMD2_start (mm)	
0	0	

All Parameters provided

Runoff Parameters

SMD	5	30	
0	0.01	0.035	0.275
20	0	0.01	0.025

Rainfall station: Cefn Cribwr

General parameters **Head Change Calculation**

	Catchment_Area (m2)	Specific_Yield	Starting_Head
SW	1,756,799	0.13	7.4
GW	1,756,799		

Rainfall Multiplier	1
PE Multiplier	1

User-defined time series

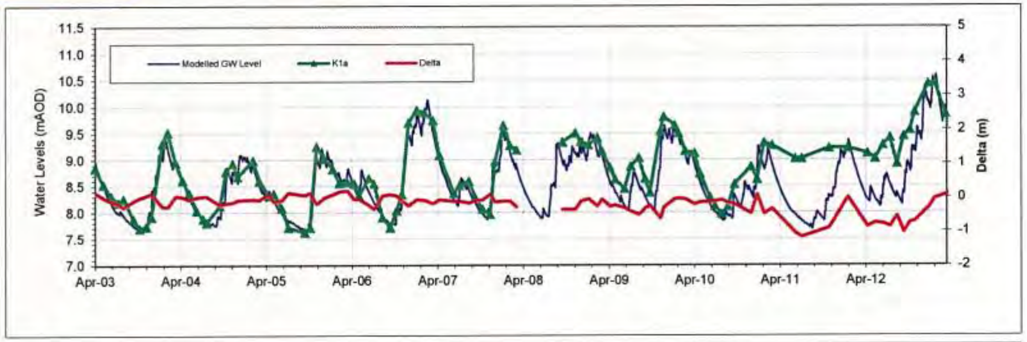
Precipitation (mm) - Sheet SMB calcs
Potential evapotranspiration (mm) - Sheet SMB calcs
Nb Change cells references on water balance sheet

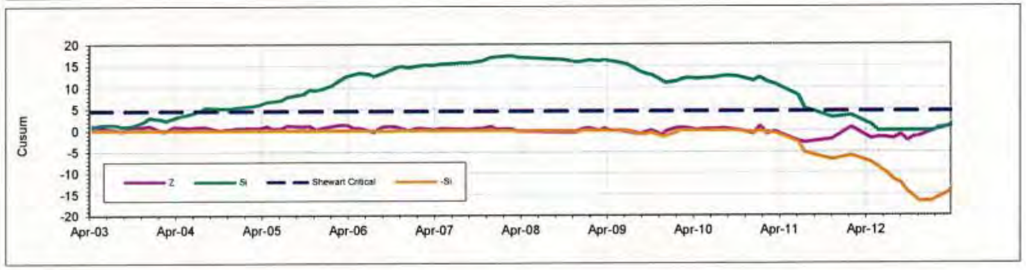
Stores Parameters		
EffectiveOvertop Specific Yield	1	
Store Starting Volume	0	m
v_top multiplier	7	
Overtop	12	
V top	9	
T Slow	90	days
T Fast	4	days
Runoff multiplier	0	

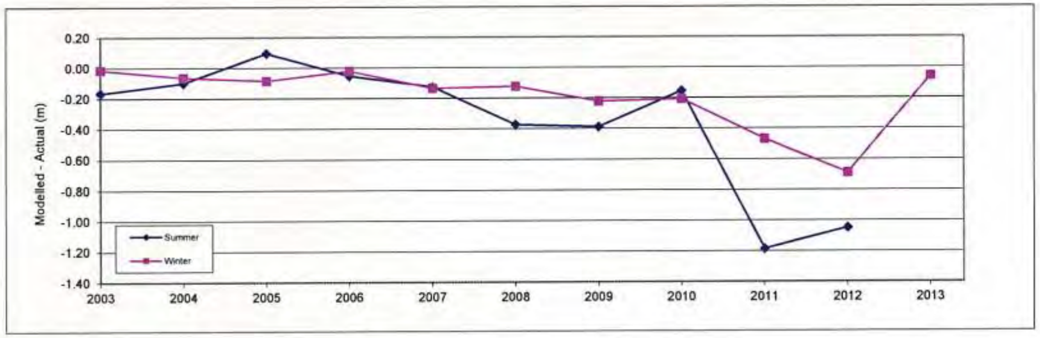
Stats

K (not permeability!!)	0.25	m
Mean Error (modelled - Actual)	-0.26	m
ST Dev Error	0.34	m
Mean summer error	-0.31	m
Max Summer error	-0.02	m
Min Summer error	-0.69	m
Dummy value for Z_i	0	

NOTE: Summer goes from July to October Included; Winter goes from November to June the following year.







Runoff Calculation Parameters (Location K1b)

Parameters for Soil Moisture Balance

Drying constant (mm)	Direct percolation (%)	Drying curve slope
75	25	0.3
SMD1_start (mm)	SMD2_start (mm)	
0	0	

All Parameters provided

Runoff Parameters

SMD	5	30	
0	0.01	0.035	0.275
20	0	0.01	0.025

Rainfall station: Kenfig

General parameters **Head Change Calculation**

	Catchment_Area (m2)	Specific_Yield	Starting_Head
SW	3,560,000	0.2	9.3
GW	3,560,000		

Rainfall Multiplier	1
PE Multiplier	1

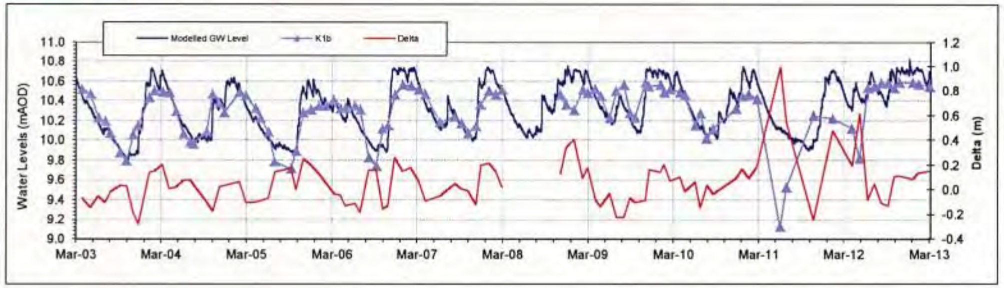
User-defined time series

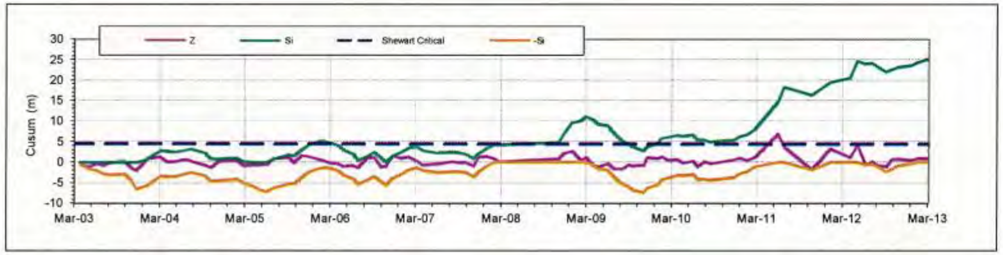
Precipitation (mm) - Sheet SMB calcs
Potential evapotranspiration (mm) - Sheet SMB calcs
Nb Change cells references on water balance sheet

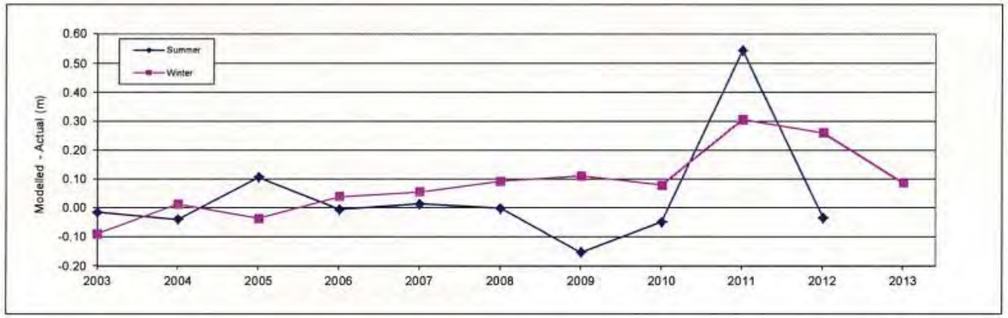
Stores Parameters		
EffectiveOvertop Specific Yiel	1	
Store Starting Volume	1	m
Overtop	10.7	mAOD
T Slow	160	days
T Fast	4	days
Runoff multiplier	0	

Stats

K (not permeability!!)	0.05	m
Mean Error (modelled - Actua	0.02	m
ST Dev Error	0.14	m
Mean summer error	-0.01	m
Max Summer error	0.31	m
Min Summer error	-0.09	m
Dummy value for Z_i	0	







Runoff Calculation Parameters (Location K2a)

Parameters for Soil Moisture Balance

Drying constant (mm)	Direct percolation (%)	Drying curve slope
75	10	0.3
SMD1_start (mm)	SMD2_start (mm)	
0	0	

All Parameters provided

Runoff Parameters

SMD	5	30	
0	0.01	0.035	0.275
20	0	0.01	0.025

Rainfall station: Cefn Cribwr

General parameters **Head Change Calculation**

	Catchment_Area (m2)	Specific_Yield	Starting_Head
SW	1,756,799	0.1	7.2
GW	1,756,799		

Rainfall Multiplier	1
PE Multiplier	1

User-defined time series

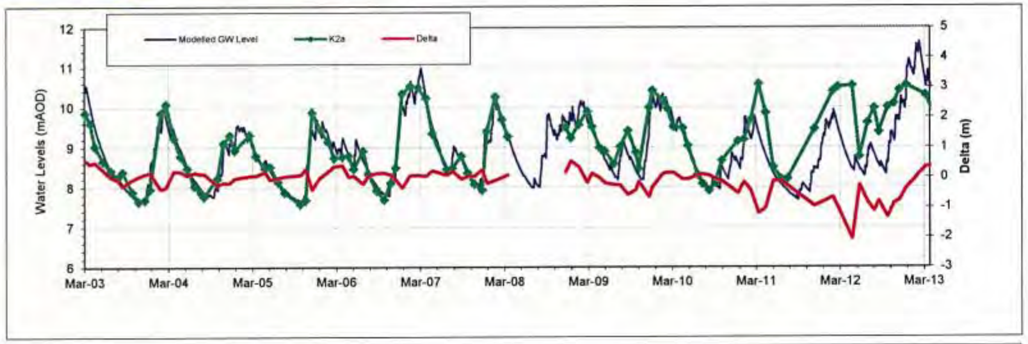
Precipitation (mm) - Sheet SMB calcs
Potential evapotranspiration (mm) - Sheet SMB calcs
Nb Change cells references on water balance sheet

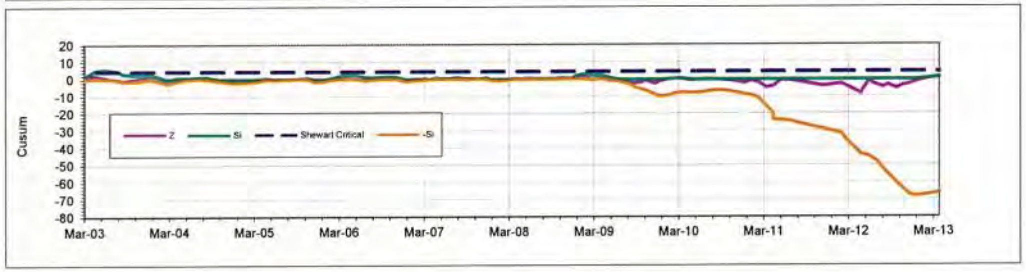
Stores Parameters		
EffectiveOvertop Specific Yield	1	
Store Starting Volume	0	m
v_top multplier	7	
Overtop	12	
V top	10	
T Slow	100	days
T Fast	4	days
Runoff multiplier	0	

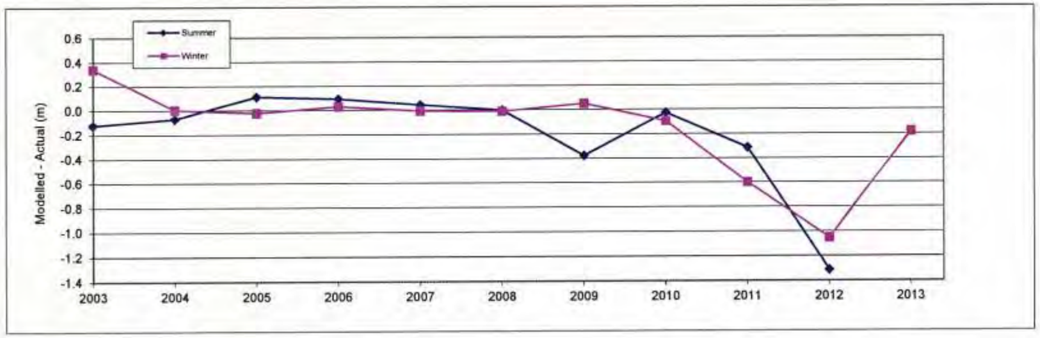
Stats

K (not permeability!!)	0.25	m
Mean Error (modelled - Actual)	0.00	m
ST Dev Error	0.25	m
Mean summer error	-0.25	m
Max Summer error	0.34	m
Min Summer error	-1.05	m
Dummy value for Z_i	0	

NOTE: Summer goes from July to October Included;
Winter goes from November to June the following year.







Runoff Calculation Parameters (Location K2b)

Parameters for Soil Moisture Balance

Drying constant (mm)	Direct percolation (%)	Drying curve slope
75	25	0.3
SMD1_start (mm)	SMD2_start (mm)	
0	0	

All Parameters provided

Runoff Parameters

SMD	5	30	
0	0.01	0.035	0.275
20	0	0.01	0.025

Rainfall station: Kenfig

General parameters **Head Change Calculation**

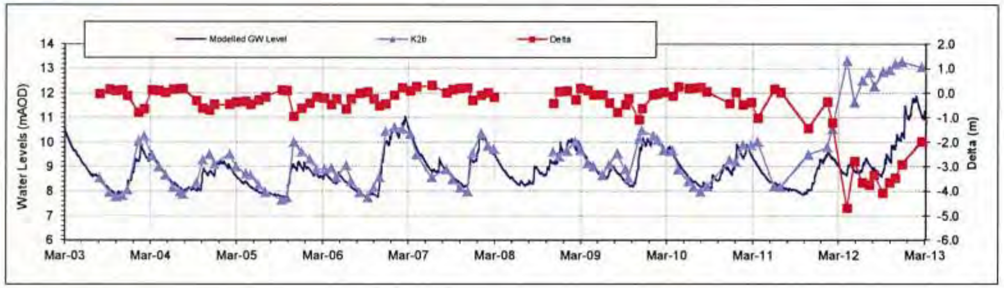
Rainfall Multiplier	1		
PE Multiplier	1		

	Catchment_Area (m2)	Specific_Yield	Starting_Head
SW	3,560,000	0.1	6.9
GW	3,560,000		

User-defined time series

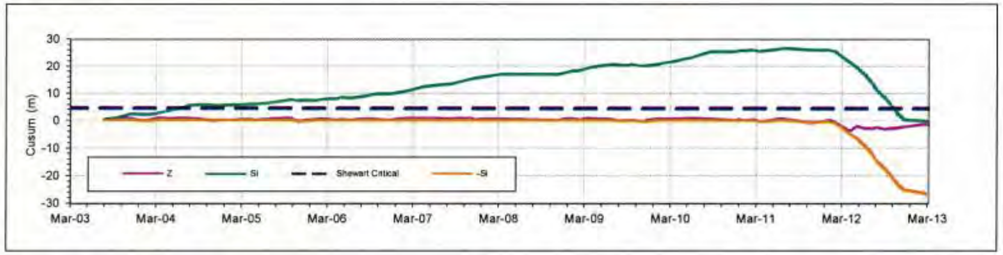
Precipitation (mm) - Sheet SMB calcs
Potential evapotranspiration (mm) - Sheet SMB calcs
Nb Change cells references on water balance sheet

Stores Parameters		
EffectiveOvertop Specific Yiel	1	
Store Starting Volume	0.5	m
Overtop	13	mAOD
T Slow	130	days
T Fast	4	days
Runoff multiplier	0	

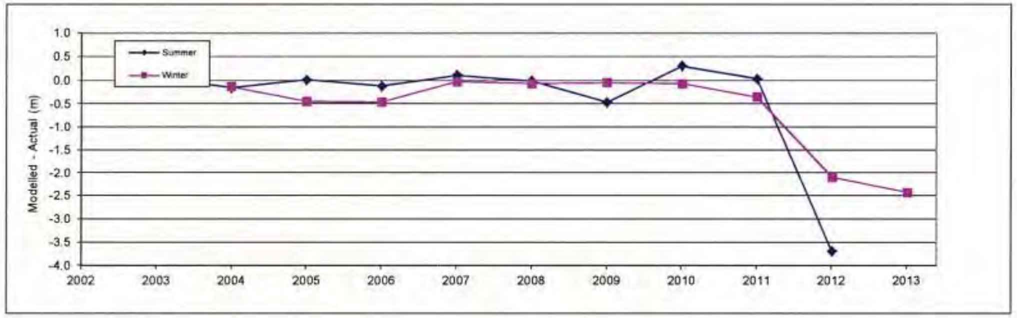


Stats

K (not permeability!!)	0.05	m
Mean Error (modelled - Actual	-0.58	m
ST Dev Error	1.10	m
Mean summer error	-0.67	m
Max Summer error	-0.02	m
Min Summer error	-2.42	m
Dummy value for Z_i	0	



NOTE: Summer goes from July to October Included; Winter goes from November to June the following year.



Runoff Calculation Parameters (Kenfig Pool)

Parameters for Soil Moisture Balance (Sand Dunes)

	Drying constant (mm)	Direct percolation (%)	Drying curve slope
Sand	75	25	0.3
Till		100	
	SMD1_start (mm)	SMD2_start (mm)	
	0	0	

All Parameters provided

Runoff Parameters for sand dunes

SMD	5	30	
0	0	0	0
20	0	0	0

Runoff Parameters for glacial till

SMD	5	30	
0	0.075	0.2	0.3
20	0	0.1	**0.075**

Rainfall station: Kenfig

	Sand	Lake
Rainfall Multiplier	1	1
PE Multiplier	1	1

Permeability of sand dunes

15 m/day

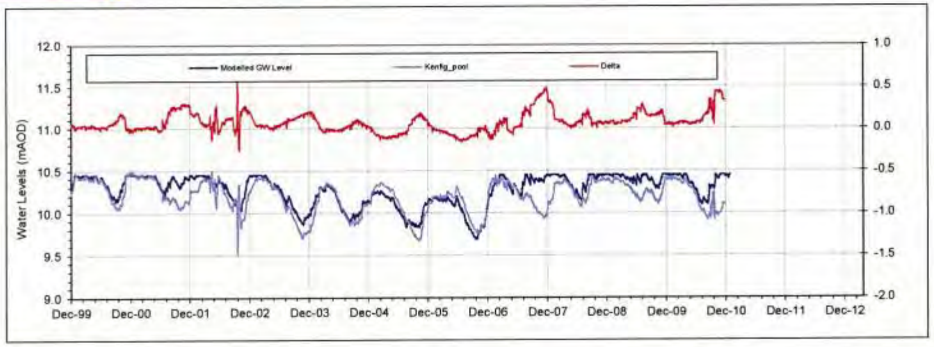
General parameters | **Head Change Calculation**

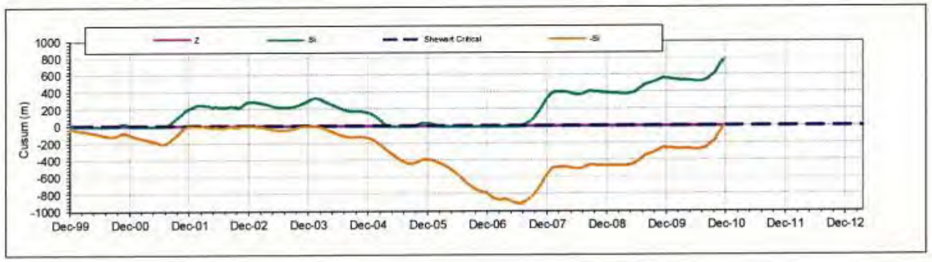
	Catchment_Area (m2)	Specific_Yield	Starting_Head
Dunes	3,318,000	0.15	9.2
Till	1,000,000		
Lake	242,000		
TOTAL	1,242,000		

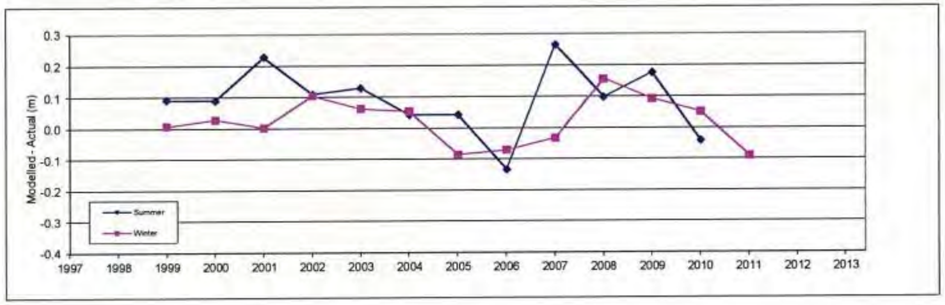
Lake parameters		
Starting level of lake	9	mAOD
Overtop level of the lake	10.45	mAOD
PE multiplier	1.5	
Area of lake	242000	m2
Depth of inflow section	10	m
Depth of outflow section	12.5	m
Width of Inflow section	500	m
Width of Outflow section	500	m
Distance to sea	1020	m
Mean sea outflow level	6	mAOD

Stores Parameters for Sand Dunes		
EffectiveOvertop Specific Yiel	1	
Store Starting Volume	0.45	m
Overtop	11.1	mAOD
T Slow	130	days
T Fast	4	days
Runoff multiplier	1	

Stats		
K (not permeability!!)	0.05	m
Mean Error (modelled - Actual	0.07	m
ST Dev Error	0.11	m
Mean summer error	0.12	m
Max Summer error	0.16	m
Min Summer error	-0.09	m
Dummy value for Z_i	0	







Runoff Calculation Parameters (Location D4)

Parameters for Soil Moisture Balance

Drying constant (mm)	Direct percolation (%)	Drying curve slope
75	25	0.3
SMD1_start (mm)	SMD2_start (mm)	
0	0	

All Parameters provided

Runoff Parameters

SMD	5	30	
0	0.01	0.035	0.275
20	0	0.01	0.025

Rainfall station: Schwyll

General parameters **Head Change Calculation**

	Catchment_Area (m2)	Specific_Yield	Starting_Head
SW	1756799	0.09	7.3
GW	1756799		

Rainfall Multiplier	1
PE Multiplier	1

User-defined time series

Precipitation (mm) - Sheet SMB calcs
Potential evapotranspiration (mm) - Sheet SMB calcs
Nb Change cells references on water balance sheet

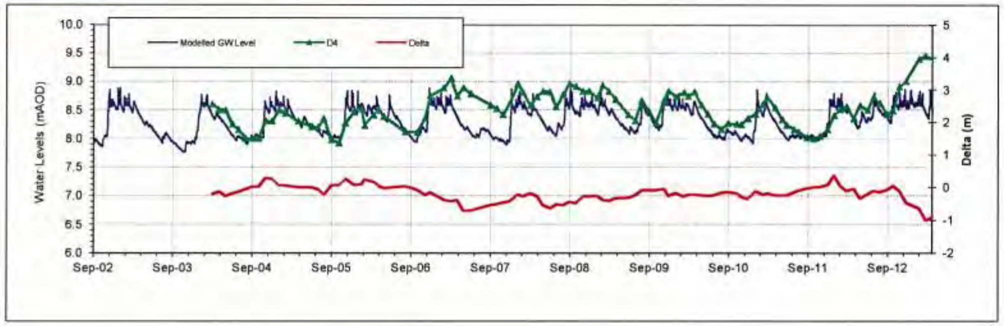
Stores Parameters

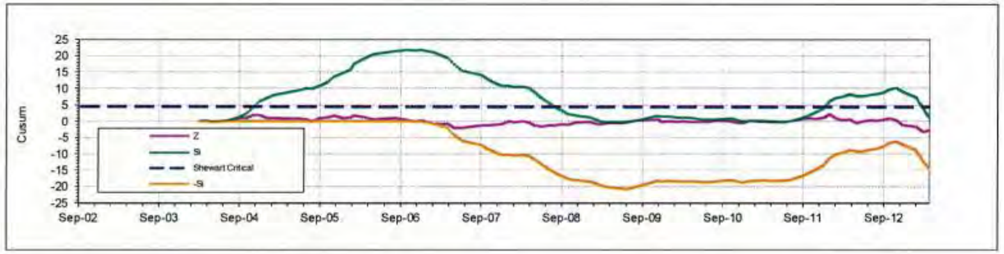
EffectiveOvertop Specific Yield	1	
Store Starting Volume	0	m
v_top multiplier	7	
Overtop	8.6	
V top	8	
T Slow	130	days
T Fast	1	days
Runoff multiplier	0	

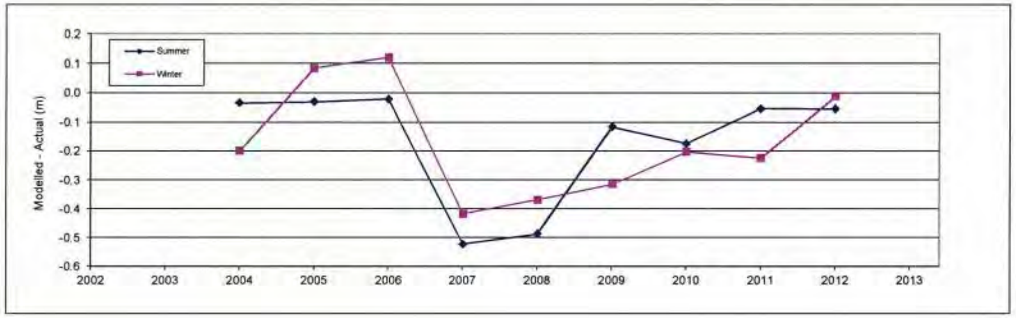
Stats

K (not permeability!!)	0.05	m
Mean Error (modelled - Actual)	-0.20	m
ST Dev Error	0.25	m
Mean summer error	-0.16	m
Max Summer error	0.12	m
Min Summer error	-0.65	m
Dummy value for Z_i	0	

NOTE: Summer goes from July to October Included; Winter goes from November to June the following year.







Runoff Calculation Parameters (Location D7)

Parameters for Soil Moisture Balance

Drying constant (mm)	Direct percolation (%)	Drying curve slope
75	25	0.3

SMD1_start (mm)	SMD2_start (mm)
0	0

All Parameters provided

Runoff Parameters

SMD	5	30	
0	0.01	0.035	0.275
20	0	0.01	0.025

Rainfall station: Schwyll

Rainfall Multiplier 1
PE Multiplier 1

General parameters **Head Change Calculation**

	Catchment_Area (m2)	Specific_Yield	Starting_Head
SW	1,756,799	0.09	6
GW	1,756,799		

User-defined time series

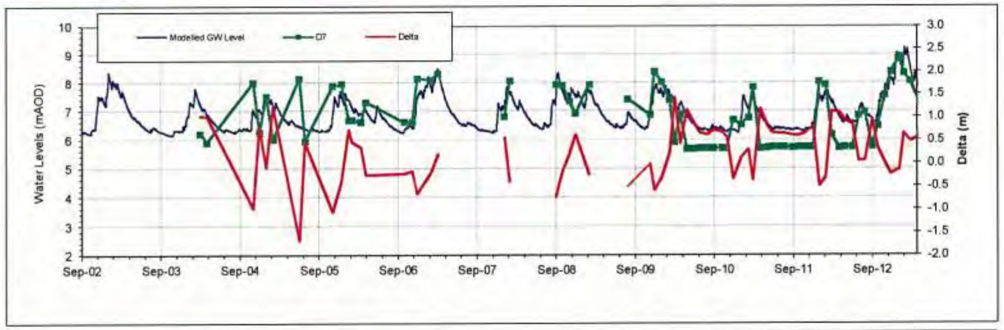
Precipitation (mm) - Sheet SMB calcs
Potential evapotranspiration (mm) - Sheet SMB calcs
Nb Change cells references on water balance sheet

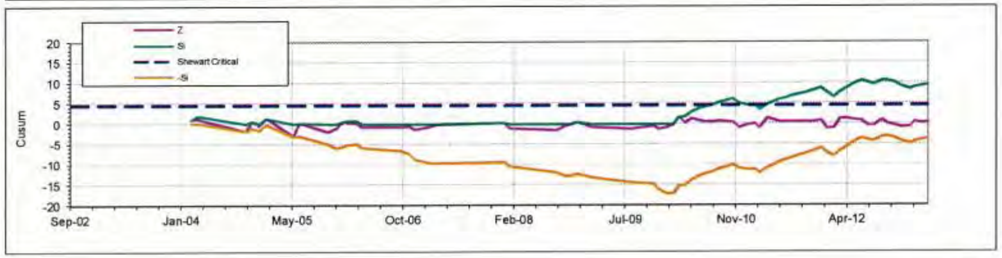
Stores Parameters		
EffectiveOvertop Specific Yield	1	
Store Starting Volume	0	m
v_top multiplier	2	
Overtop	10	
V top	12	
T Slow	60	days
T Fast	4	days
Runoff multiplier	0	

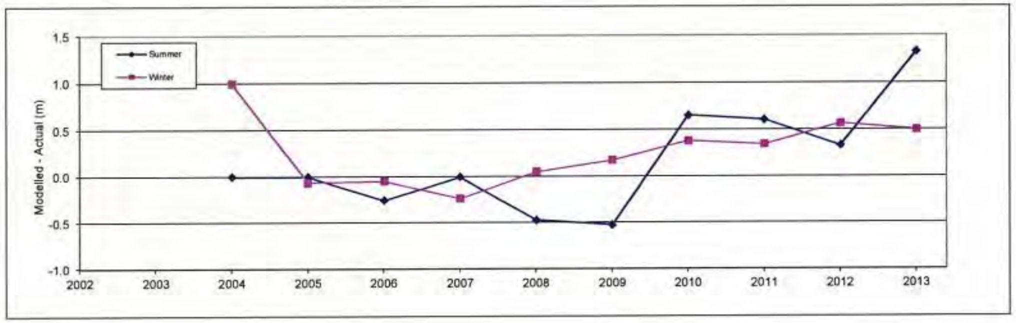
Stats

K (not permeability!!)	0.05	m
Mean Error (modelled - Actual)	0.30	m
ST Dev Error	0.65	m
Mean summer error	0.36	m
Max Summer error	1.00	m
Min Summer error	-0.23	m
Dummy value for Z_i	0	

NOTE: Summer goes from July to October Included;
Winter goes from November to June the following year.







Runoff Calculation Parameters (Location D8)

Parameters for Soil Moisture Balance

Drying constant (mm)	Direct percolation (%)	Drying curve slope
75	25	0.3
SMD1_start (mm)	SMD2_start (mm)	
0	0	

All Parameters provided

Runoff Parameters

SMD	5	30	
0	0.01	0.035	0.275
20	0	0.01	0.025

Rainfall station: Schwyll

General parameters **Head Change Calculation**

Rainfall Multiplier 1
PE Multiplier 1

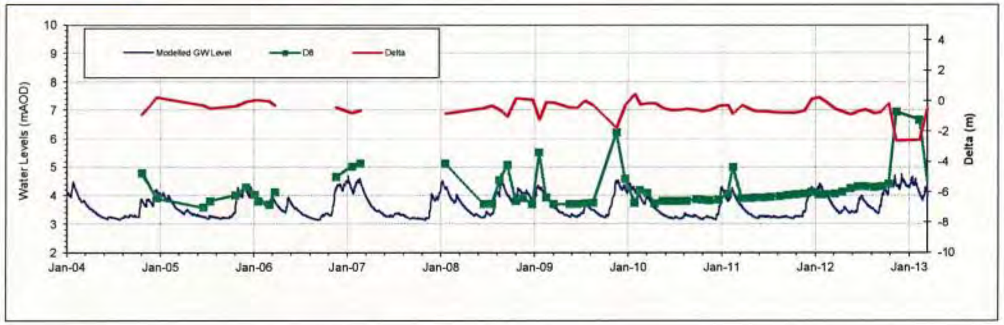
Suspect data

	Catchment_Area (m2)	Specific_Yield	Starting_Head
SW	1,756,799	0.1	3
GW	1,756,799		

User-defined time series

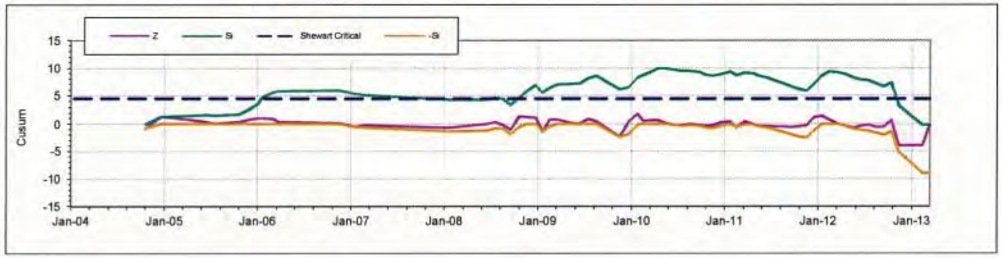
Precipitation (mm) - Sheet SMB calcs
Potential evapotranspiration (mm) - Sheet SMB calcs
Nb Change cells references on water balance sheet

Stores Parameters		
EffectiveOvertop Specific Yield	1	
Store Starting Volume	0	m
V_top multiplier	7	
Overtop	4.5	
V top	18	
T Slow	50	days
T Fast	4	days
Runoff multiplier	0	

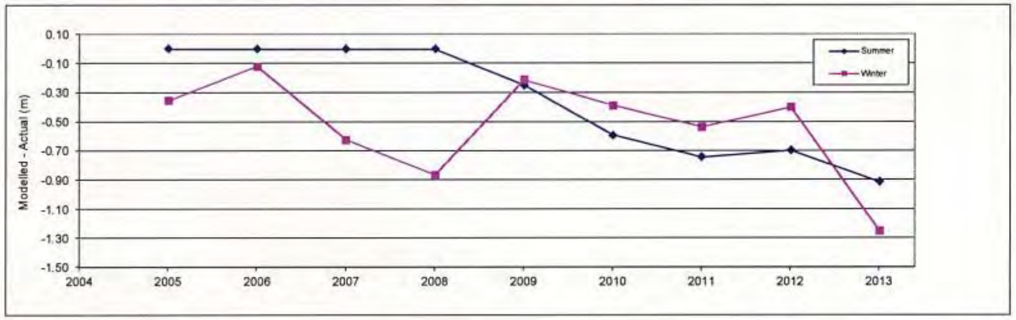


Stats

K (not permeability!!)	0.05	m
Mean Error (modelled - Actual)	-0.52	m
ST Dev Error	0.52	m
Mean summer error	-0.61	m
Max Summer error	-0.12	m
Min Summer error	-1.25	m
Dummy value for Z_i	0	



NOTE: Summer goes from July to October Included;
Winter goes from November to June the following year.



Runoff Calculation Parameters (Location I)

Parameters for Soil Moisture Balance

Drying constant (mm)	Direct percolation (%)	Drying curve slope
75	25	0.3
SMD1_start (mm)	SMD2_start (mm)	
0	0	

All Parameters provided

Runoff Parameters

SMD	5	30	
0	0.01	0.035	0.275
20	0	0.01	0.025

Rainfall station: Schwyll

Rainfall Multiplier 1
PE Multiplier 1

General parameters **Head Change Calculation**

	Catchment_Area (m2)	Specific_Yield	Starting_Head
SW	1,756,799	0.09	1.9
GW	1,756,799		

User-defined time series

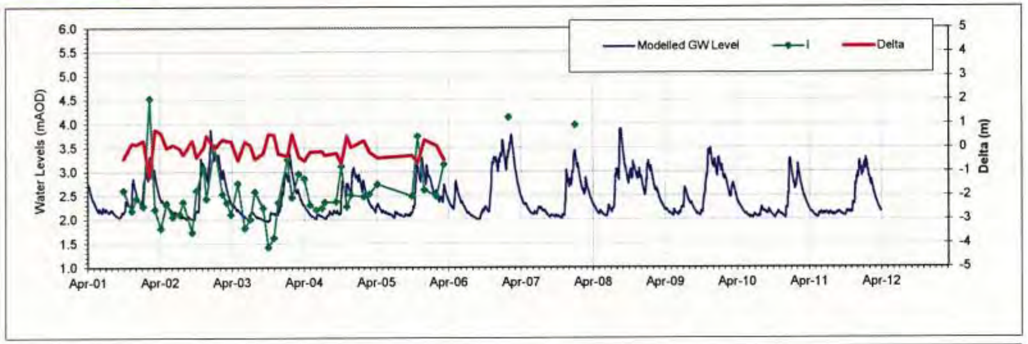
Precipitation (mm) - Sheet SMB calcs
Potential evapotranspiration (mm) - Sheet SMB calcs
Nb Change cells references on water balance sheet

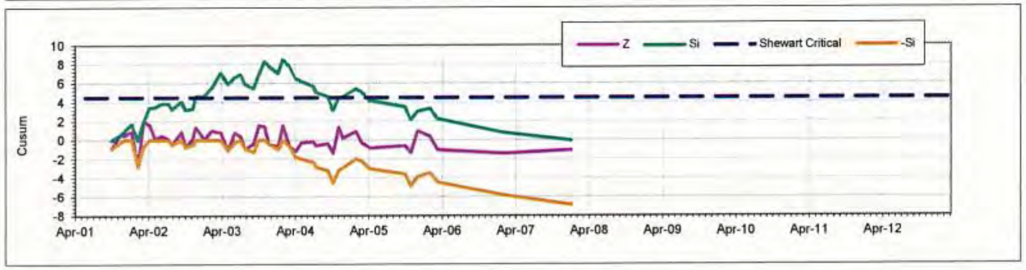
Stores Parameters		
EffectiveOvertop Specific Yield	1	
Store Starting Volume	0	m
v_top multiplier	7	
Overtop	10	
V top	12	
T Slow	40	days
T Fast	4	days
Runoff multiplier	0	

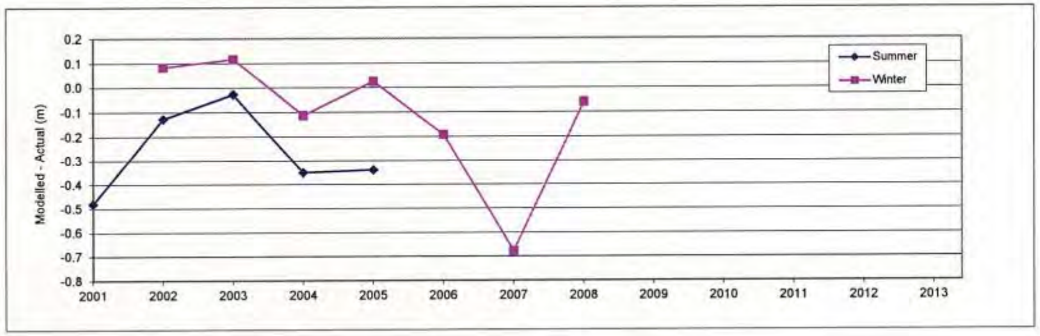
Stats

K (not permeability!!)	0.05	m
Mean Error (modelled - Actual)	-0.08	m
ST Dev Error	0.42	m
Mean summer error	-0.20	m
Max Summer error	0.12	m
Min Summer error	-0.68	m
Dummy value for Z_i	0	

NOTE: Summer goes from July to October Included;
Winter goes from November to June the following year.







Runoff Calculation Parameters (Location L)

Parameters for Soil Moisture Balance

Drying constant (mm)	Direct percolation (%)	Drying curve slope
75	25	0.3
SMD1_start (mm)	SMD2_start (mm)	
0	0	

All Parameters provided

Runoff Parameters

SMD	5	30	
0	0.01	0.035	0.275
20	0	0.01	0.025

Rainfall station: Schwyll

General parameters **Head Change Calculation**

	Catchment_Area (m2)	Specific_Yield	Starting_Head
SW	1,756,799	0.12	10.2
GW	1,756,799		

Rainfall Multiplier	1
PE Multiplier	1

User-defined time series

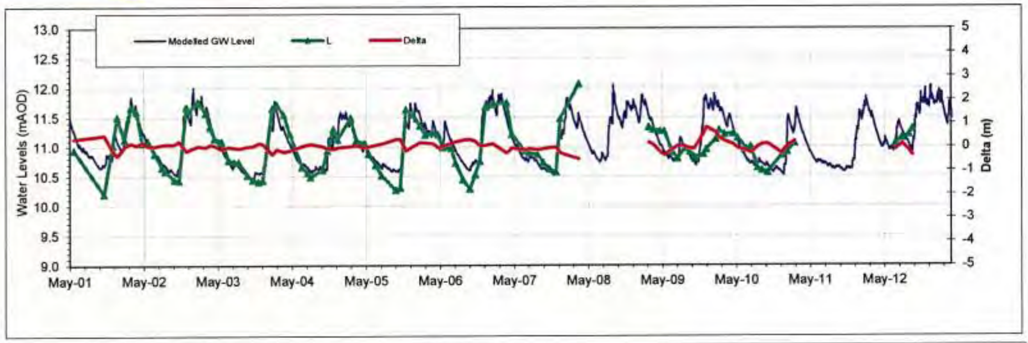
Precipitation (mm) - Sheet SMB calcs
Potential evapotranspiration (mm) - Sheet SMB calcs
Nb Change cells references on water balance sheet

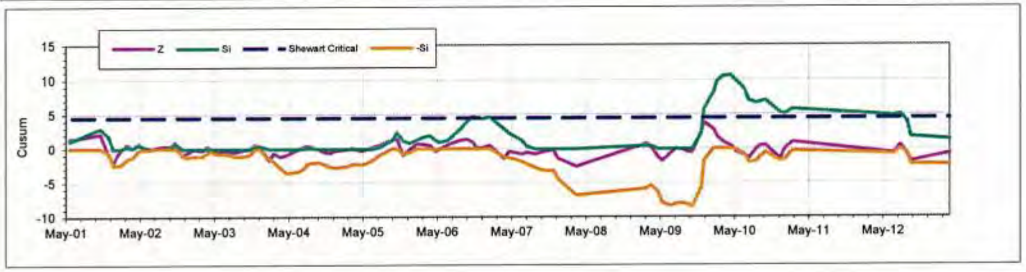
Stores Parameters		
EffectiveOvertop Specific Yield	1	
Store Starting Volume	0	m
v_top multiplier	7	
Overtop	11.8	
V top	12	
T Slow	90	days
T Fast	4	days
Runoff multiplier	0	

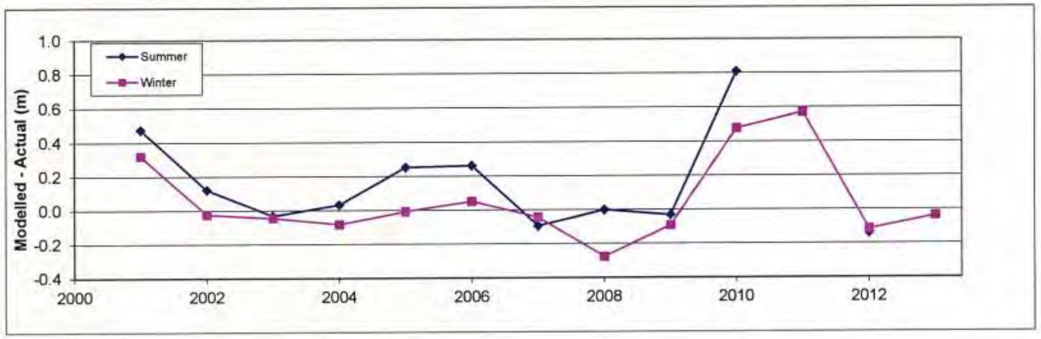
Stats

K (not permeability!!)	0.25	m
Mean Error (modelled - Actual)	0.03	m
ST Dev Error	0.21	m
Mean summer error	0.05	m
Max Summer error	0.57	m
Min Summer error	-0.28	m
Dummy value for Z_i	0	

NOTE: Summer goes from July to October Included;
Winter goes from November to June the following year.







Runoff Calculation Parameters (Location D)

Parameters for Soil Moisture Balance

Drying constant (mm)	Direct percolation (%)	Drying curve slope
75	25	0.3
SMD1_start (mm)	SMD2_start (mm)	
0	0	

All Parameters provided

Runoff Parameters

SMD	5	30	
0	0.01	0.035	0.275
20	0	0.01	0.025

Rainfall station: Cefn Cribwr

Rainfall Multiplier	1
PE Multiplier	1

General parameters **Head Change Calculation**

	Catchment_Area (m2)	Specific_Yield	Starting_Head
SW	1,420,082	0.012	10
GW	1,420,082		

User-defined time series

Precipitation (mm) - Sheet SMB calcs
Potential evapotranspiration (mm) - Sheet SMB calcs
Nb Change cells references on water balance sheet

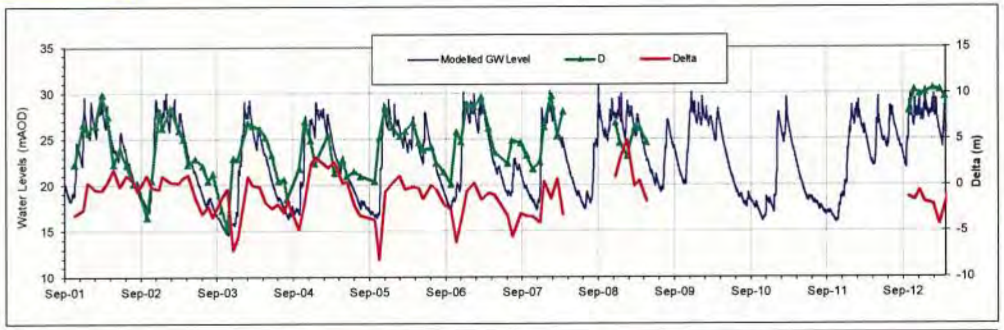
Stores Parameters

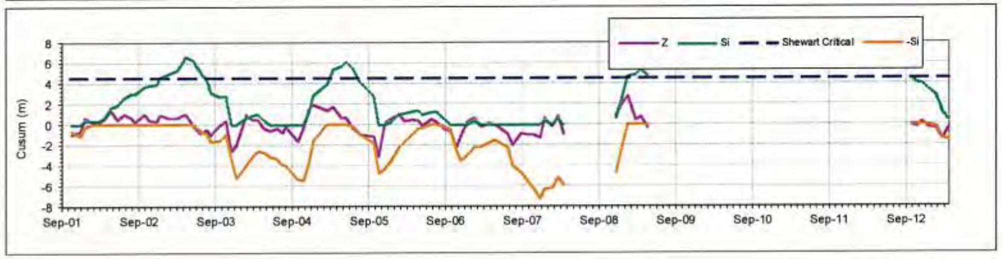
EffectiveOvertop Specific Yield	1	
Store Starting Volume	0.1	m
Overtop	28	
v_top multiplier	5	
V top	25	
T Slow	120	days
T Fast	4	days
Runoff multiplier	0	

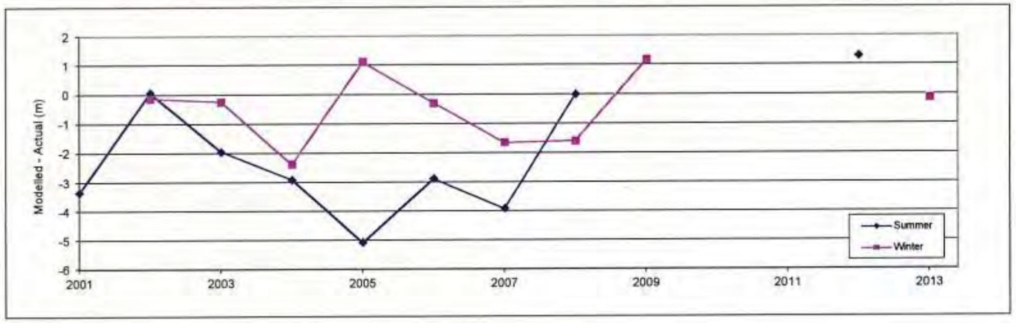
Stats

K (not permeability!!)	0.25	m
Mean Error (modelled - Actual)	-1.17	m
ST Dev Error	2.23	m
Mean summer error	-2.54	m
Max Summer error	1.18	m
Min Summer error	-2.37	m
Dummy value for Z_i	0	

NOTE: Summer goes from July to October Included; Winter goes from November to June the following year.







Runoff Calculation Parameters (Location G)

Parameters for Soil Moisture Balance

Drying constant (mm)	Direct percolation (%)	Drying curve slope
75	25	0.3

SMD1_start (mm)	SMD2_start (mm)
0	0

All Parameters provided

Runoff Parameters

SMD	5	30	
0	0.01	0.035	0.275
20	0	0.01	0.025

Rainfall station: Cefn Cribwr

General parameters **Head Change Calculation**

	Catchment_Area (m2)	Specific_Yield	Starting_Head
SW	1,420,082	0.003	24
GW	1,420,082		

Rainfall Multiplier	1
PE Multiplier	1

User-defined time series

Precipitation (mm) - Sheet SMB calcs
Potential evapotranspiration (mm) - Sheet SMB calcs
Nb Change cells references on water balance sheet

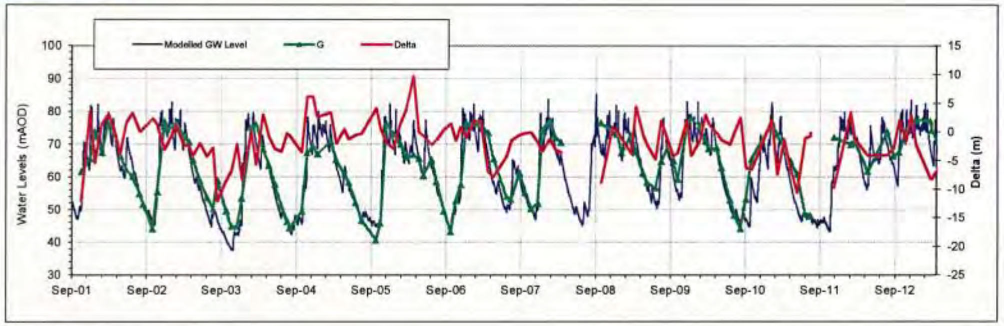
Stores Parameters

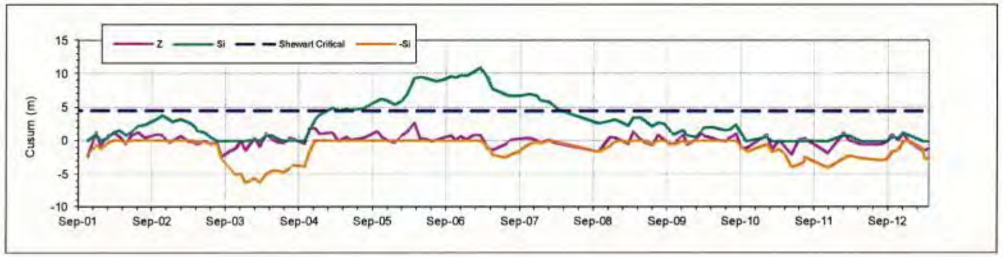
EffectiveOvertop Specific Yield	2	
Store Starting Volume	0.1	m
v_top multiplier	2	
Vtop	40	
Overtop	75	
T Slow	110	days
T Fast	4	days
Runoff multiplier	1	

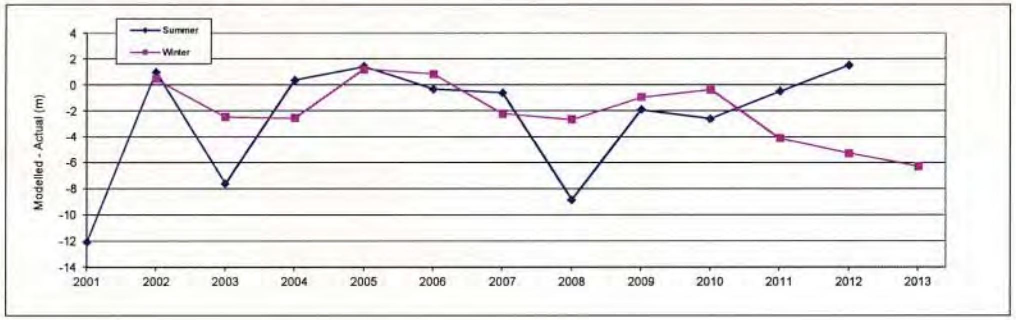
Stats

K (not permeability!!)	0.25	m
Mean Error (modelled - Actual)	-1.71	m
ST Dev Error	4.23	m
Mean summer error	-1.47	m
Max Summer error	1.24	m
Min Summer error	-6.25	m
Dummy value for Z_i	0	

NOTE: Summer goes from July to October Included;
Winter goes from November to June the following year.







Runoff Calculation Parameters (Location T95/01)

Parameters for Soil Moisture Balance

Drying constant (mm)	Direct percolation (%)	Drying curve slope
75	25	0.3
SMD1_start (mm)	SMD2_start (mm)	
0	0	

All Parameters provided

Runoff Parameters

SMD	5	30	
0	0.01	0.035	0.275
20	0	0.01	0.025

Rainfall station: Cefn Cribwr

General parameters **Head Change Calculation**

	Catchment_Area (m2)	Specific_Yield	Starting_Head
SW	1420082	0.003	20
GW	1420082		

Rainfall Multiplier	1
PE Multiplier	1

User-defined time series

Precipitation (mm) - Sheet SMB calcs
Potential evapotranspiration (mm) - Sheet SMB calcs
Nb Change cells references on water balance sheet

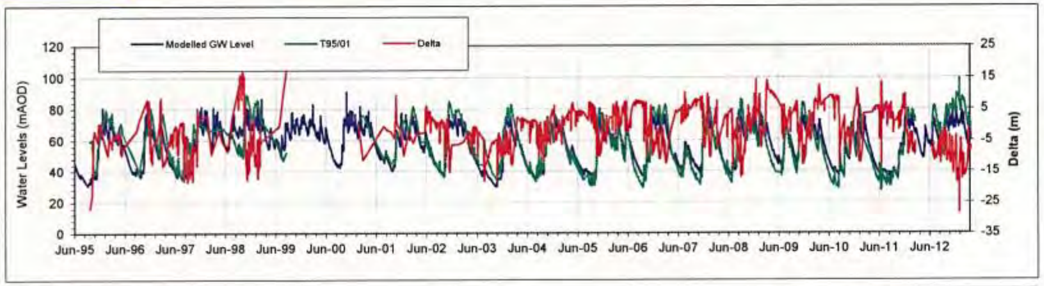
Stores Parameters

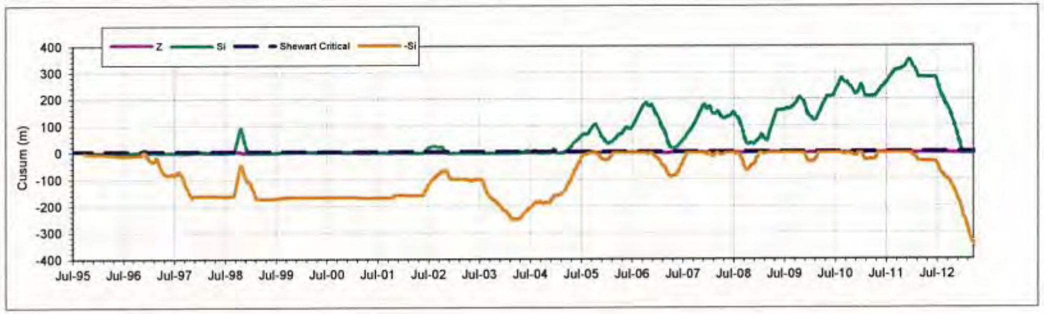
Overtop	71	mAOD
Store Starting Volume	0.1	m
V top	25	
T Slow	90	days
T Fast	4	days
Vtop multiplier	2	
Runoff multiplier	0	

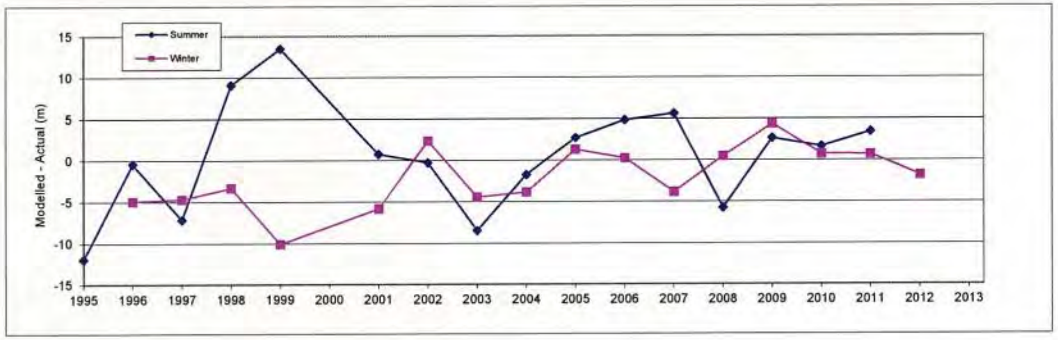
Stats

K (not permeability!!)	0.25	m
Mean Error (modelled - Actual)	-1.34	m
ST Dev Error	6.59	m
Mean summer error	-0.43	m
Max Summer error	4.40	m
Min Summer error	-10.09	m
Dummy value for Z_i	0	

NOTE: Summer goes from July to October Included;
Winter goes from November to June the following year.







Runoff Calculation Parameters (Location 17b) - NB This is an abstraction well so some data affected by pumping

Parameters for Soil Moisture Balance

Drying constant (mm)	Direct percolation (%)	Drying curve slope
75	25	0.3
SMD1_start (mm)	SMD2_start (mm)	
0	0	

All Parameters provided

Runoff Parameters

SMD	5	30	
0	0.01	0.035	0.275
20	0	0.01	0.025

Rainfall station: Cefn Cribwr

General parameters | **Head Change Calculation**

	Catchment_Area (m2)	Specific_Yield	Starting_Head
SW	1420082	0.012	9
GW	1420082		

Rainfall Multiplier 1
PE Multiplier 1

User-defined time series

Precipitation (mm) - Sheet SMB calcs
Potential evapotranspiration (mm) - Sheet SMB calcs
Nb Change cells references on water balance sheet

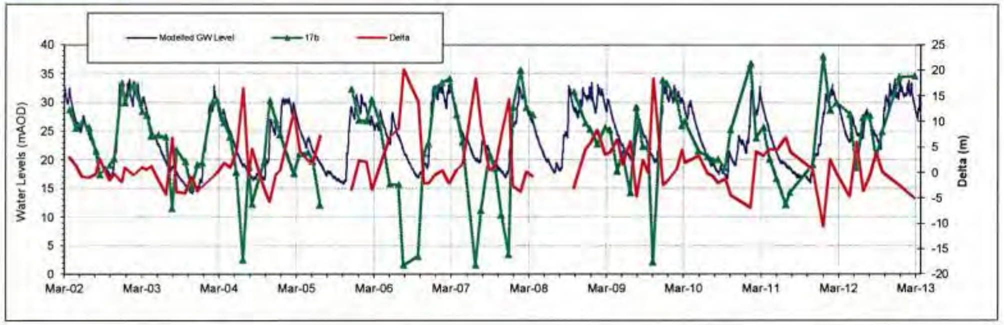
Stores Parameters

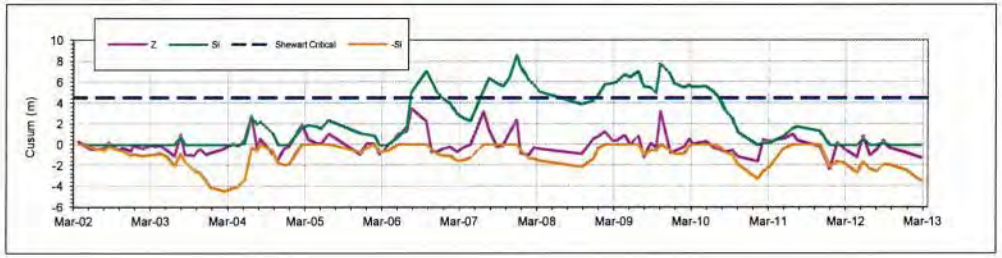
EffectiveOvertop Specific Yield	1	
Store Starting Volume	0.1	m
v_top multiplier	2	
v_Top	28	
Overtop	32	
T Slow	120	days
T Fast	4	days
Runoff multiplier	0	

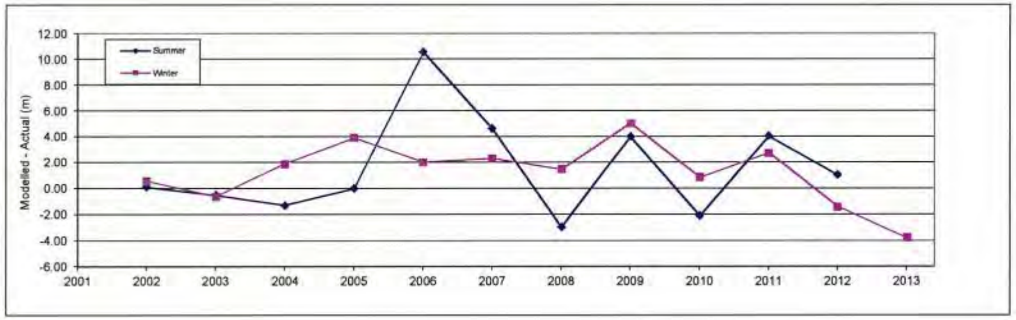
Stats

K (not permeability!!)	0.25	m
Mean Error (modelled - Actual)	1.65	m
ST Dev Error	5.31	m
Mean summer error	1.73	m
Max Summer error	5.04	m
Min Summer error	-3.77	m
Dummy value for Z_i	0	

NOTE: Summer goes from July to October Included;
Winter goes from November to June the following year.







Runoff Calculation Parameters (Location A-a)

Parameters for Soil Moisture Balance

Drying constant (mm)	Direct percolation (%)	Drying curve slope
75	25	0.3
SMD1_start (mm)	SMD2_start (mm)	
0	0	

All Parameters provided

Runoff Parameters

SMD	5	30	
0	0.01	0.035	0.275
20	0	0.01	0.025

Rainfall station: Cefn Cribwr

General parameters **Head Change Calculation**

	Catchment_Area (m2)	Specific_Yield	Starting_Head
SW	1,756,799	0.05	7
GW	1,756,799		

Rainfall Multiplier	1
PE Multiplier	1

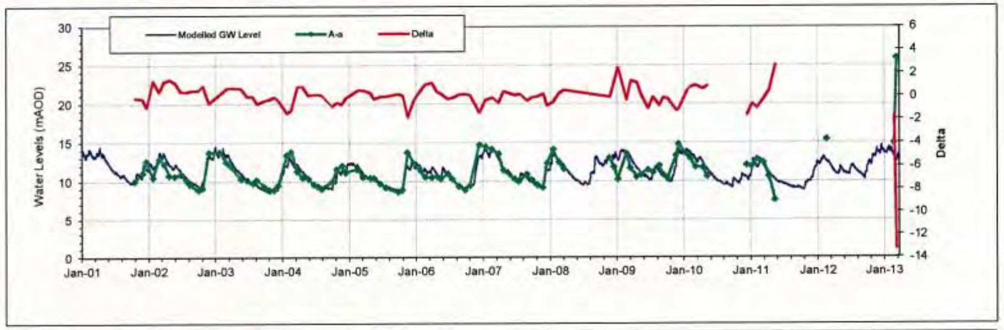
User-defined time series

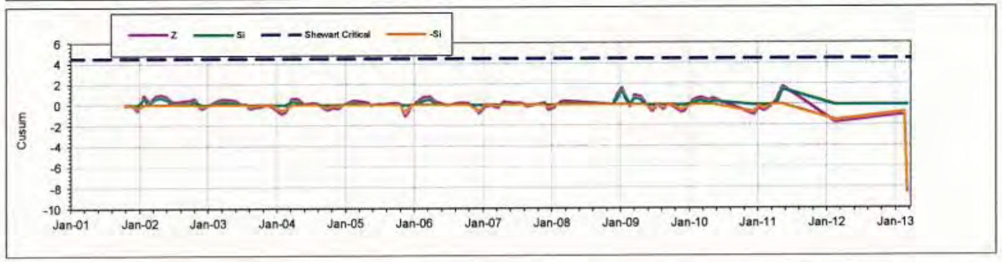
Precipitation (mm) - Sheet SMB calcs
Potential evapotranspiration (mm) - Sheet SMB calcs
Nb Change cells references on water balance sheet

Stores Parameters		
EffectiveOvertop Specific Yield	1	
Store Starting Volume	0	m
v_top multiplier	7	
Overtop	14	
V top	12	
T Slow	125	days
T Fast	10	days
Runoff multiplier	0	

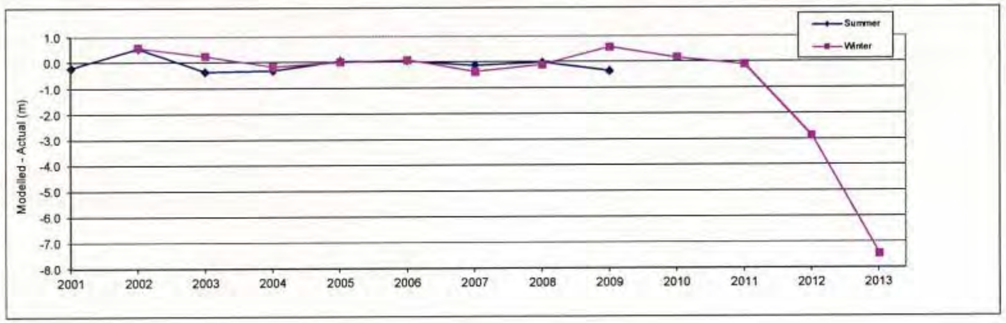
Stats

K (not permeability!!)	0.25	m
Mean Error (modelled - Actual)	-0.11	m
ST Dev Error	1.57	m
Mean summer error	-0.08	m
Max Summer error	0.60	m
Min Summer error	-7.45	m
Dummy value for Z_i	0	





NOTE: Summer is from July to October inclusive;
Winter goes from November to June the following year.



Runoff Calculation Parameters (Location B-a)

Parameters for Soil Moisture Balance

Drying constant (mm)	Direct percolation (%)	Drying curve slope
75	25	0.3
SMD1_start (mm)	SMD2_start (mm)	
0	0	

All Parameters provided

Runoff Parameters

SMD	5	30	
0	0.01	0.035	0.275
20	0	0.01	0.025

Rainfall station: Cefn Cribwr

General parameters **Head Change Calculation**

Rainfall Multiplier 1
PE Multiplier 1

	Catchment_Area (m2)	Specific_Yield	Starting_Head
SW	1,756,799	0.05	5.7
GW	1,756,799		

User-defined time series

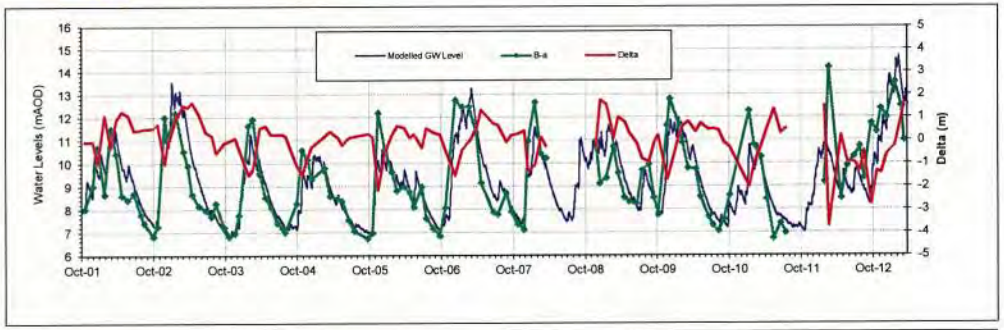
Precipitation (mm) - Sheet SMB calcs
Potential evapotranspiration (mm) - Sheet SMB calcs
Nb Change cells references on water balance sheet

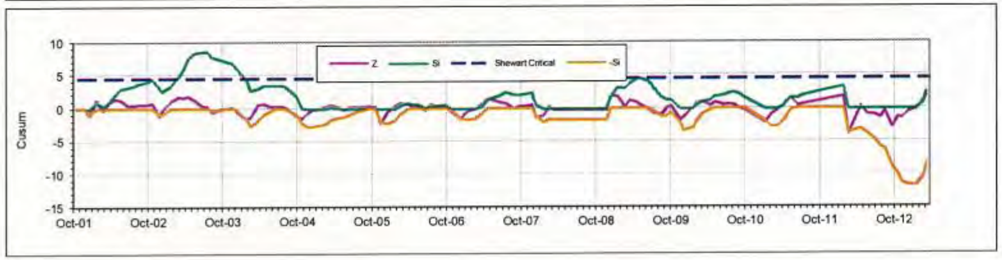
Stores Parameters		
EffectiveOvertop Specific Yield	1	
Store Starting Volume	0	m
v_top multiplier	7	
Overtop	15	
V top	17	
T Slow	100	days
T Fast	4	days
Runoff multiplier	0	

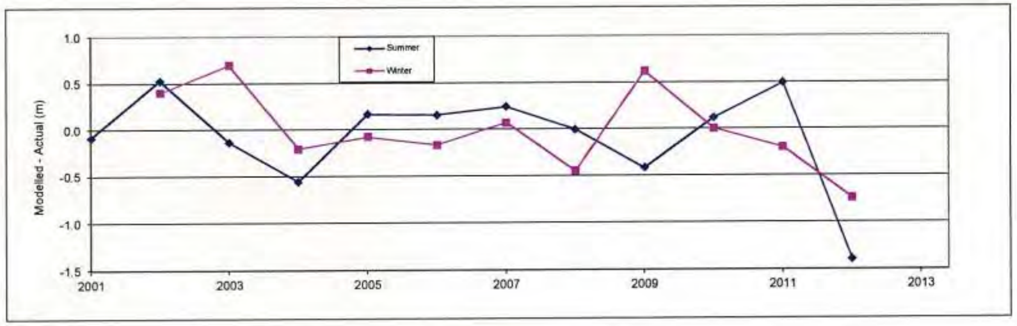
Stats

K (not permeability!!)	0.25	m
Mean Error (modelled - Actual)	-0.01	m
ST Dev Error	0.93	m
Mean summer error	-0.16	m
Max Summer error	0.70	m
Min Summer error	-0.74	m
Dummy value for Z_i	0	

NOTE: Summer goes from July to October Inclusive;
Winter goes from November to June the following year.







Runoff Calculation Parameters (Location N-a)

Parameters for Soil Moisture Balance

Drying constant (mm)	Direct percolation (%)	Drying curve slope
75	10	0.3

SMD1_start (mm)	SMD2_start (mm)
0	0

All Parameters provided

Runoff Parameters

SMD	5	30	
0	0.01	0.035	0.275
20	0	0.01	0.025

Rainfall station: Cefn Cribwr

General parameters **Head Change Calculation**

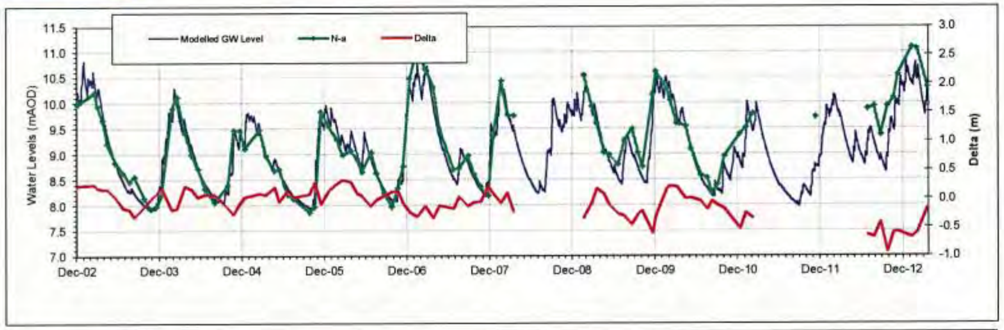
	Catchment_Area (m2)	Specific_Yield	Starting_Head
SW	1756799	0.1	7.6
GW	1756799		

Rainfall Multiplier	1
PE Multiplier	1

User-defined time series

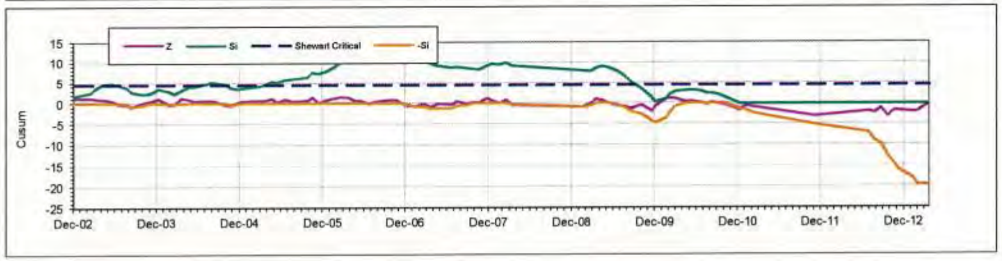
Precipitation (mm) - Sheet SMB calcs
Potential evapotranspiration (mm) - Sheet SMB calcs
Nb Change cells references on water balance sheet

Stores Parameters		
EffectiveOvertop Specific Yield	1	
Store Starting Volume	0	m
v_top multiplier	7	
Overtop	10.6	
V top	9	
T Slow	90	days
T Fast	4	days
Runoff multiplier	0	

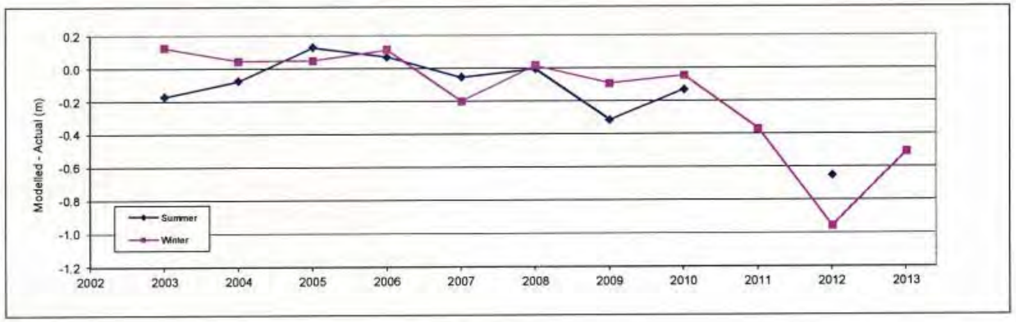


Stats

K (not permeability!!)	0.25	m
Mean Error (modelled - Actual)	-0.09	m
ST Dev Error	0.27	m
Mean summer error	-0.17	m
Max Summer error	0.13	m
Min Summer error	-0.96	m
Dummy value for Z_i	0	



NOTE: Summer goes from July to October Included;
Winter goes from November to June the following year.



Appendix D - Technical Note on Calculation of Climate Based Assessment Criteria and Associated Statistical Tools

Report reference: 6227 WMP Cornelly Quarry, August 2007
Report status: WMP Update August 2007

CONTENTS

FIGURES

APPENDICES

1 INTRODUCTION

1.1 Background

Cornelly Quarry (the "Quarry") is the largest quarry in Wales providing over 1 million tonnes of limestone per year, principally for the steel mill at Port Talbot. It is also an important supplier of aggregates into the local construction industry.

In 1997, applications were made to Bridgend County Borough Council under the Environment Act, 1995 (Review of old mineral permissions – ROMP), for determination of a scheme of conditions in respect of the area of the Quarry covered by those planning permissions (the "ROMP application"). Separate applications were made in respect of the nearby Grove and Gaens' Quarries. The applications were referred to the Secretary of State for Wales in May 1998 (Gaens') and July 1998 (Cornelly and Grove). Due to the commonality of issues at these sites, it was decided that they should be determined as a group. The National Assembly for Wales (now the Welsh Assembly Government) subsequently took on the role of determining authority for the applications.

An Environmental Impact Assessment (EIA) in connection with the ROMP applications for the Quarry was submitted voluntarily in 2004 (WynThomasGordonLewis, 2004). The EIA was based on the continuation and extension of current water management practices at the Quarry. The EIA included a set of proposed planning conditions.

One of the proposed new planning conditions submitted in the EIA was the requirement to develop a Water Management Plan (WMP) for the Quarry (WynThomasGordonLewis, 2004 Appendix 8, C No. 9). The objective of the WMP is to guide the Quarry Operator in its management of water at the Quarry such that any adverse environmental impacts resulting from these activities can be minimised. In order to achieve this, the WMP will:

- Specify the monitoring activities required;
- Outline how the resultant data should be reviewed in order to determine whether the operation of the Quarry has affected any of the monitoring sites;
- Outline the options for management of water at the Quarry and how these could be adjusted in light of any effects detected at any of the monitoring sites.

1.2 Objectives of this Technical Note

For the purposes of the WMP, the Quarry Operator and Regulator need to be able to determine whether any future variations in monitoring data at any of the monitoring sites are due to the effects of climate or are due to other causes (such as land use change, private abstraction and quarry dewatering). There are two components to this technical issue:

1. A mechanism is required that can allow the behaviour of water levels at a monitoring site to be predicted under future climatic conditions (a Climate Based Assessment Criterion);
2. Statistical tools are required that will allow an assessment to be made as to the timing and scale of any Deviation[1] between the water levels predicted by the Climate Based Assessment Criterion and those measured in the future.

1.3 Approach

This technical note presents details of the two tools described above. Section 2 presents a generic description of calculations to be used for generating Climate Based Assessment Criteria. These calculations were originally presented as part of the conceptual model report that underpinned the EIA and were reviewed in detail by the Environment Agency at that time. The calculations have been updated with more recent climate data using several demonstration datasets from the monitoring sites in the area.

[1] In this context, Deviation is defined as the occurrence of a statistically significant difference between the behaviour measured at a site and the behaviour that would be anticipated under 'natural' conditions.

Section 3.1 presents details of statistical techniques that it is proposed should be used to determine whether a Deviation has occurred. This is a two stage process:

1. Firstly standard control chart techniques are applied to identify periods during which there is a sudden or sustained change in the relationship between the observed data and the Climate Based Assessment Criterion.
2. Then statistical tests are applied to confirm whether there has been a statistically significant change in the relationship between the observed data and the Climate Based Assessment Criterion during this period. If a statistically significant change is confirmed, this is considered to be a Deviation.

The use of these techniques is demonstrated in Section 3.2 by artificially adjusting a segment of time series data of a sample data set by a fixed amount to illustrate the sensitivity of the techniques to small changes in water level.

Note that, in this technical note, the techniques are only discussed in terms of water levels. However, they could be equally applicable to flow data.

2 CALCULATION OF CLIMATE BASED ASSESSMENT CRITERIA

2.1 Introduction

This section provides a generic discussion of the calculations that will be used to derive Climate Based Assessment Criterion and the data that they require as inputs. It then illustrates how these calculations can be used to generate a time series of predicted water levels at a site for given antecedent climatic conditions.

The calculations to derive Climate Based Assessment Criteria are based on daily soil moisture balance calculations which use rainfall and potential evapotranspiration data as inputs. The calculations have a number of parameters that affect the way in which the soil moisture balance operates and which control the division of outputs between actual evapotranspiration, runoff and infiltration to groundwater.

The infiltration to groundwater is passed into a '1D store'. This is a simple algebraic device that is used as a 'groundwater model': the rate of outflow in the store is proportional to the level of water in the store. The constant of proportionality of the 1D store is one of the parameters that can be used to adjust the temporal behaviour of both the water levels in the store and the resultant outflows. The water level in the store can be converted to an equivalent measured groundwater level by means of a 'specific yield'.

The values of the parameters used in the calculations presented here were selected partially on the basis of values commonly used for these parameters in regional water resource assessments and partly by 'calibration' against local flow data (e.g. quarry abstraction rates, some stream flow data). These values have not been adjusted since the calculations were originally developed to support the conceptual model in 2003. The match between the simulated and measured water levels at these sites since that time provides a measure of confidence in the calculations and their parameterisation for those sites.

2.2 Data

2.2.1 Rainfall data

The following rainfall data sets are available from the Environment Agency:

Cefn Cribwr (1) – Daily rainfall data for the period Jan 1981 to Jan 02 (with some gaps)

Cefn Cribwr (2) – Daily rainfall data for the period Jan 02 to Dec 05 (with some gaps)

Schwyll - Daily rainfall data for the period Dec 91 to Sept 06 (with some gaps)

Margam - Daily rainfall data for the period Feb 93 to July 06 (with some gaps)

In addition, staff at Kenfig National Nature Reserve monitor rainfall at Kenfig at intermittent (daily/weekly intervals). Data are available for the period Jan 2000 to May 06.

The calculations presented in the conceptual model report (ESI, 2003) were based on the Cefn Cribwr (1) data series. This is an appropriate site for the calculation of the limestone block around the quarry as it is at a similar elevation. As monitoring at this site has been discontinued and there is relatively little overlap with the new monitoring site here, gaps in the data series have primarily been filled by reference to the Schwyll rainfall series. Conversion was by means of the equation Cefn Cribwr (1) = 1.27 x Schwyll (based on the ratio of long term average rainfall at the two sites for periods during which reliable data are available at both sites). Ultimately, it is anticipated that this will be replaced by reference to data from a new rain gauge to be installed at Cornelly Quarry itself.

It is clear from the available data from Kenfig Nature Reserve that rainfall here is lower than at Cefn Cribwr (1) due to the lower elevation of the former. In order to convert the continuous daily time series from Cefn Cribwr (1) to an appropriate series for calculations for the sand dunes, the Cefn Cribwr (1) data have been converted by means of the equation

Kenfig = 0.885 x Cefn Cribwr (1) (based on the ratio of long term average rainfall at the two sites for periods during which reliable data are available at both sites) for the period when there is no data at Kenfig. For the period for which there are rainfall data at Kenfig, the daily rainfall at Schwyll has been factored so that the monthly totals are the same as those measured at Kenfig.

2.2.2 Potential Evapotranspiration data (PE)

Weekly PE data for MORECS square 155 were converted to daily values by distributing the weekly total evenly across each day of the week. There is less spatial variation in PE data and the outputs from the calculations are less sensitive to this parameter and so this has not been varied spatially.

2.3 Soil Moisture Balance Calculations

Recharge to the groundwater system has been calculated using a Penman two store soil moisture balance model implemented in an Excel spreadsheet.

Prior to passing rainfall to the soil moisture store, any runoff is removed. In areas in which the ground surface is relatively impermeable this may be a relatively significant amount (say 10-20%). On areas of permeable aquifer (e.g. limestone or dune sands) runoff is likely to be relatively low although water may effectively bypass the soil zone (see below).

The Penman store model consists of an upper and a lower soil store. The depth of the upper store is the depth up to which roots are able to draw as much water as required. At greater depths of store, water is only available to plants at a reduced rate. A bypass mechanism allowing direct percolation to the unsaturated zone via e.g. macropores or root channels may also be included. Referring to the schematic diagram in Figure 2.1 (a), the Penman store model works in the following manner.

The status of the model is wetting if precipitation is greater than potential evapotranspiration (i.e. $P\text{-}PE>0$), otherwise it is drying ($P\text{-}PE<0$).

In wetting mode, the direct percolation (i.e. bypass of the soil zone) is a constant percentage of the effective precipitation, i.e. $f\ (P\text{-}PE)$, where f is the proportional factor (1). The remaining water $(1\text{-}f)\ (P\text{-}PE)$ infiltrates the upper soil store (2). When the upper store is full, the excess begins to saturate the lower soil store (3). When the lower soil store is full the excess leaves the lower soil store as percolation to the unsaturated zone (4).

In drying mode, whilst the upper soil store is not dry (5), the soil moisture deficit of the store increases by the shortfall in potential evapotranspiration once precipitation has been taken into account, i.e.

$$\Delta SMD_1 = (PE - P) \qquad \text{if} \quad SMD_1 < D_c$$

where

SMD_1 is the soil moisture deficit of the upper store

ΔSMD_1 is the change in the soil moisture deficit of the upper store

D_c is the drying constant.

When the upper soil store is dry, drying of the lower store takes place at a lower rate:

$$\Delta SMD_2 = \gamma(PE - P) \qquad \text{if} \quad SMD_1 = D_c$$

where the factor γ represents the drying curve slope

Typical parameter values are as follows f=15%, D_c=75 mm, γ=0.3. For the karstic Carboniferous Limestone areas it is likely that the bypass percentage will be higher and a value of 25% has been used.

The output from the soil moisture deficit model (infiltration to groundwater) has then been processed by passing through a two stage store as illustrated on Figure 2.1 (b). The store is characterised by three parameters:

Time constant for lower release

Time constant for upper release

Level for upper release to be activated

The methodology effectively uses catchment averaged rainfall and PE data series to calculate total catchment flow (e.g. in a river). This approach has proved to be very successful in simulating saturated flow in small to medium sized aquifer systems and is used extensively by the Environment Agency in Thames Region (Catchmod).

2.4 Comparison with Data

Whilst the approach described above has been proven to be widely applicable in a variety of settings (including Carboniferous Limestone areas), the effectiveness of the calculations needs to be demonstrated by comparison with field data for the current study area. Comparison of outputs with observed river flows is presented in Appendix D of ESI, 2003. The text below focuses on comparison with observed groundwater levels as this is the primary interest of this technical note.

The status of the 'groundwater store' provides a prediction of groundwater levels in the aquifer. A good match between store volume and groundwater levels indicates that the calculations are effectively simulating the temporal variation in groundwater recharge and discharge from the aquifer system.

2.4.1 Kenfig Dunes

Calculations were developed for the sand dune system at Kenfig using the synthesised daily Kenfig time series (see Section 2.2.1). Key parameters used are:

Sy=0.2 (dune sands)
Store time constant = 180 days
Runoff= 8% (average)
Drying constant (D_c)= 75 mm
Drying curve (γ) = 0.3
Direct percolation (f) = 25%

The results of this calculation are shown in Figure 2.2. Clearly there are a number of simplifications in trying to simulate a complex structure such as the dunes in such a simple manner. However, overall the qualitative fit to the data is reasonable. The summary statistics for the calculations include:

LTA (Feb 93- Jul 06) effective precipitation = 632 mm/a

Percentage of recharge 'overtopping' = 2% (not much 'overtopping' effect in this hydrograph)

The overall range of the simulated and observed groundwater levels during the period of overlap is very close (8.94 to 10.51 mAOD and 8.91 to 10.50 mAOD respectively). There is a slight bias of the calculations to simulate levels lower than those observed (0.1 m on average). However, the current simulation was retained as, on average it was considered to simulate levels better during the critical summer periods. This difference is relatively small compared to the range of levels simulated (7% of range).

2.4.2 Carboniferous Limestone

A similar calculation was set up to simulate recharge processes in the Carboniferous Limestone around Cornelly Quarry. The following parameters were used in the calculations:

Sy=0.005
Runoff=*0%,*
f=25%,
D_c=75 mm,
γ=0.3

Figure 2.3 shows the comparison between the simulated groundwater levels and actual data for borehole 96/11 (just to the east of Cornelly Quarry). There is a good qualitative fit between simulated and observed data. The parameterisation of the calculations has not been modified for the presence of the quarry as it is not clear whether the nature of the workings will increase or decrease the total recharge available (reduced evaporation due to the absence of plants but increased evaporation in areas of open water). The surface of the quarry floors is generally permeable due to the effects of blasting and there does not appear to be significant amounts of runoff.

There is some indication that there has been some drawdown at this site over the period simulated and this is consistent with its position in the immediate vicinity of the quarry.

2.4.3 New Mill Farm Catchment

In this case the groundwater levels in the Triassic marginal facies at the South Cornelly Borehole were simulated. The following parameters were used in the calculations:

Sy=0.015
Runoff=*0%,*
f=25%,
D_c=75 mm,
γ=0.3

The observed and simulated groundwater levels are shown on Figure 2.4. Again, there is a reasonable degree of correlation between the

2.5 Summary

The proposed approach for assessing the effect of climatic variations (principally rainfall rates) on groundwater levels has been shown to be generally successful for the main types of hydrogeological conditions of relevance to the WMP. It is therefore concluded that this approach is appropriate for the purposes required by the WMP.

3 STATISTICAL TOOLS

Control charts are a method commonly used in to monitor processes and produce an early warning whenever a situation deviates from 'normal'. The two main types of control charts used in groundwater monitoring are the Shewart and the Cu-Sum charts. These techniques are used to identify periods during which there is a sudden or sustained change in the relationship between the observed data and the Climate Based Assessment Criteria.

Once such a period has been identified, supplementary statistical tests can be applied to confirm whether there is a statistically significant change in the relationship between the observed data and the Climate Based Assessment Criteria during this period compared to the relationship beforehand (baseline). The choice of tests depends on whether the differences between the observed data and the Climate Based Assessment Criteria are normally distributed or not. The two sample t-test is a well known test that is appropriate for use with populations that are normally distributed with the same variance around their respective means. The Wilcoxen Rank-Sum Test for Two Groups is a non-parametric test that can be used with non-normally distributed datasets.

Section 3.1 presents a brief technical description of the implementation of these methods. This is followed in Section 3.2 by an illustration of the application of these techniques to determine whether there is any deviation between observed water level data and outputs from the calculations presented in Section 2.

3.1 Approach

3.1.1 Shewart Charts

The Shewart control chart is used to detect relatively sudden changes in a process under investigation (e.g. rapid increase/decrease of groundwater level).

Assuming that $x_1, x_2, \dots, x_n$ are n differences between the simulated and measured groundwater levels at the times $t_1, t_2, \dots, t_n$., a Shewart control chart of these differences is obtained by standardising the values of x_i as follows:

$$z_i = \frac{x_i - m}{s}; \qquad i = 1, 2, \dots, n$$

where: m and s are the average and the unbiased standard deviation of the x_i, $i = 1, 2, \dots, n$,

and then plotting them versus the times $t_1, t_2, \dots, t_n$.

In order to identify when the process has deviated from 'normal' the standardised data z_i are compared to a threshold Z (control limit). When the z_i exceed the control limit the process is declared to be 'beyond normal range'. Gibbons suggests that a value of Z of 4.5 should be taken as a level at which a statistically significant change is considered to have occurred.

3.1.2 Cu-Sum Charts

The Cumulative Summation (Cu-Sum) approach not only focuses on the current monitoring value, but also incorporates information from the previous observations. The main advantage of a Cu-Sum over a Shewart chart, is that the Cu-Sum chart is suitable to detect slower, but systematic processes or trends which would not appear as evident by analysing the time series of the raw data or the Shewart chart. This is perhaps more common in the diffuse systems common in hydrogeology.

Assuming that $x_1, x_2, \dots, x_n$ are n differences between the simulated and measured groundwater levels at the times $t_1, t_2, \dots, t_n$.

The Cu-Sum control chart of these differences is obtained by calculating the quantity:

$$S_i = max(0, z_i - k + S_{i-1})$$

Where:

z_i are the standardised differences described in Section 3.1.1;

k is a parameter representing ½ the change that it is appropriate to try and detect (see more discussion on selection of this parameter in Section 3.2);

S_{i-1} is the value of S_i at the previous observation event.

In order to detect a when the process has fallen out of normal range, the values of S_i are compared to a threshold (or control limit) *h*. The selection of the value of *h* should be based on an assessment of the maximum value of S_i that is appropriate – this could be determined by consideration of the typical range of values of S_i during a period in which no Deviation is considered to occur. Note that, the value selected may in part be determined by the frequency of the data (i.e. a larger Cu-Sum will accumulate with daily data if the observed and simulated deviate over a 6 month period than if monthly data is used). If the frequency of monitoring changes then some allowance for this will need to be made (either by sampling the higher frequency data set to a lower frequency or by interpolating between the values in the less frequent data set).

For technical, statistical reasons the value of S_i should not fall below zero. In order to detect trends in the opposite direction, a 'negative' Cu-Sum is calculated. (i.e. the positive Cu-Sum could be used to detect when the observed data falls below the simulated level whilst the 'negative' Cu-Sum could be considered to detect when the observed data rises above that simulated).

The use of the combined Shewart-Cu-Sum control chart gives the advantages of being able to detect sudden changes in the system as well as gradual and consistent shifts, which would not be easily detected by a simple time series plot.

3.1.3 The Wilcoxon Rank-Sum test for Two Groups

The Wilcoxon Rank-Sum Test for Two Groups (Lehmann, 1975) is used to compare a two datasets to check for an increasing/decreasing average value. This is a non-parametric test and, as such, it is robust to outliers and non-detects.

In groundwater monitoring this test is often used to compare a historic dataset with a recent one in order to detect a statistical difference between the two.

To run the Wilcoxon Rank-Sum test the compliance and background data are combined and ranked from 1 to N. The Wilcoxon statistic W is then calculated as:

$$W = \sum_{i=1}^{n} C_i - \frac{1}{2}n(n+1)$$

where:

C_i denotes the ranks of the compliance samples, and

n denotes the number of compliance samples.

In order to determine whether the null hypothesis of no decreased average can be accepted an approximate Z-score for the Wilcoxon Rank-Sum test has to be compared to a critical value of W. The approximate Z-score for the Wilcoxon test is:

$$Z \approx \frac{W - E(W) - 1/2}{SD(W)};$$

where:

- *W* is the Wilcoxon statistic as above defined;

- $E(W) = \frac{1}{2}mn$ represents the expected value of *W*;
- *m* is the number of values in the background sample;
- $SD(W) = \sqrt{\frac{1}{12}mn(N+1)\left(1 - \sum_{i=1}^{g} \frac{t_i^3 - t_i}{N^3 - N}\right)}$ is the standard deviation of the *W* statistic adjusted for tied values;
- t_i represents the number of ties in the i^{th} group;
- *g* represents the number of groups of distinct tied observations.

The critical value of *W* is the upper 0.01 percentile of the standard Normal distribution $z_{0.01}$=2.326.

If the Z-score is greater than 2.326, the null hypothesis of no significant difference may be rejected.

An appropriate choice of the background and compliance datasets allows us to use the Wilcoxon Rank-Sum Test for Two Groups as a means to identify a statistical evidence of decreasing average.

3.1.4 The two sample t-test

The t-test is the most widely used method for comparing two independent groups of data, however it presents some problems when applied to non normal datasets.

The null hypothesis of the test is that the difference between the averages of the two datasets equals a number δ_0. The test statistics is:

$$t_0 = \frac{(\overline{X} - \overline{Y}) * \delta_0}{s_p \sqrt{\frac{1}{m} + \frac{1}{n}}} \qquad (1)$$

where:

$\overline{X}$ is the average of the data over the period during which a change appears to have occurred;

$\overline{Y}$ is the average of all the rest of the data;

$s_p = \sqrt{\frac{(m-1) * s_x^2 + (n-1) * s_y^2}{m+n-2}}$ is the pooled standard deviation estimate;

s_x and s_y the sample variances of the two populations;

m and *n* the sample sizes of the x and y datasets respectively

In the case that the test statistics is greater than the critical value $t_{m+n-2,1-\alpha}$ (which should be looked up in the test statistical tables), the null hypothesis should be rejected.

3.2 Application

3.2.1 Existing data sets

The application of these techniques is illustrated by reference to the observed and simulated data for the Kenfig Dunes sites as discussed in Section 2.4.1.

First the existing sequence of observed and simulated data were taken to form a 'baseline' for the statistical techniques. This created a series of pairs of observed:simulated data values at approximately monthly intervals for the period Jan 1997 to May 2006. Figure 3.1 shows the combined Cu-Sum and Shewart chart for the differences between the observed and simulated data (lower plot). The actual observed and simulated data are shown in the upper plot for comparison.

The Shewart chart shows that the control limit is not exceeded at any point in the historical time sequence.

The 'positive' Cu-Sum chart, conversely, shows that in the early part of the time series (1997 drought) there are some small but consistently positive differences between the simulated and observed data, whereas the 'negative' Cu-Sum chart shows a similar consistency in negative differences in the following part of the time series (through to the heavy rainfall in 2000). Following this there is relatively little consistent difference between simulated and observed data for the remaining time period. These differences can be seen in the observed and simulated data can be seen in the upper plot. It is not clear whether these differences are due to limitations of the calculations or inaccuracies in the input rainfall time series during this period.

The maximum (minimum) value represented in the positive (negative) Cu-Sum chart is less than +20 (greater than -26 respectively). If the calculations can be qualitatively accepted as an appropriate simulation of the groundwater conditions at this site (see discussion in Section 2.4.1) and it is considered that there is no general background trend in the differences during this period then, given that the period includes some fairly extreme climatic conditions (drought and flood), this range of Cu-Sum values can be considered to be appropriate levels at which to detect that a significant change has occurred. If the calculations could be improved to provide a more consistently good fit between observed and simulated levels, then the critical values of Cu-Sum can also be reduced.

3.2.2 Application to 'future' scenario with applied drawdown

In order to assess how effective the technique is at detecting the presence of a small but consistent drawdown in groundwater levels, a sequence of three years was added to the end of the time series and then manipulated to introduce a consistent difference between observed and simulated levels.

The data pairs for 2002 (which was considered to be a 'typical year') were repeated three times to create the 'future' sequence. This 'future' sequence was then modified by reducing the observed groundwater levels by a constant value (i.e. equivalent to a non-climate related drawdown occurring in the data). The Cu-Sum and Shewart charts were then calculated to see what size of deviation between the measured data and the simulated groundwater levels could be detected.

The results of this exercise are shown in Figures 3.2, 3.3 and 3.4 for drawdowns of 0.1, 0.2 and 0.3 m respectively. K was set at 0.05 m for this exercise, but in general will be set to half the difference that needs to be detected – for instance the Significance Criteria. The sensitivity of these results to K is shown in Figure 3.5.

From inspection of these figures, it can be seen that the Shewart approach does not detect these small but consistent changes (a change of around 0.6 m would be required to breach the Shewart control limit). The change of 0.1m would be confirmed in around 28 months (although the upward trend would have been apparent for the whole of this period), the change of 0.2 m would be confirmed in 9 months).

Comparison of the observed and simulated hydrographs in the upper plots shows that it is unlikely that a change of 0.1 m would be detected by visual comparison alone and that even a change of 0.2 m would be hard to be confident about.

A number of points are apparent from this exercise:

- The Cu-Sum approach is more sensitive and objective than visual inspection of the hydrographs.
- The length of time that the Cu-Sum takes to detect a change is inversely related to the size of the change (i.e. bigger changes are detected more quickly).
- The length of time that the Cu-Sum takes to detect a change is also related to the quality of the calculations (changes will be detected more quickly with a better match between observed and simulated data).
- The Shewart Chart is less sensitive than the Cu-Sum approach in detecting small but consistent changes. However, it would be effective at detecting a larger but more abrupt change.

3.2.3 Statistical Confirmation

The Cu-Sum chart method is dependent on time correlation effects and so, where water level changes are very gradual in comparison to the frequency of monitoring, this methodology may falsely indicate a systematic change in water levels. Once the Cu-Sum chart detects an apparent systematic change, it is therefore important to double check that a statistically significant difference is present in the data.

To achieve this, the two sample t-test or the Wilcoxon test can be used to compare the model residuals during the 'baseline' and apparently affected periods. In this case, the Wilcoxon test was used to confirm that there was a statistically significant change between the last three years of data (i.e. the period over which a change in the data was artificially applied) and the rest of the dataset. The Wilcoxon test was used as the model residuals were not normally distributed.

3.3 Summary

The example presented above suggests that the combined Shewart-Cu-Sum approach should be effective at detecting both abrupt changes in observed and simulated water levels and small but consistent changes. The sensitivity of these techniques in detecting changes in water level is primarily controlled by the quality of the fit between the observed and simulated data over a representative 'baseline' period. Where a good fit cannot be achieved, simpler approaches may be appropriate.

Once a period of apparent variation between the Climate Based Assessment Criterion and the observed data has been identified, it is important to carry out supplementary statistical tests to confirm this conclusion. To achieve this, the two sample t-test or the Wilcoxon test can be used.

In all cases, conditions at adjacent sites should be considered wherever possible in order to confirm the conclusions of techniques such as these.

4 REFERENCES

ESI, 2003. Cornelly Group of Quarries: Conceptual model of the local hydrogeology

R. Gibbons "Statistical Methods for Groundwater Monitoring" John Wiley & Sons, Inc

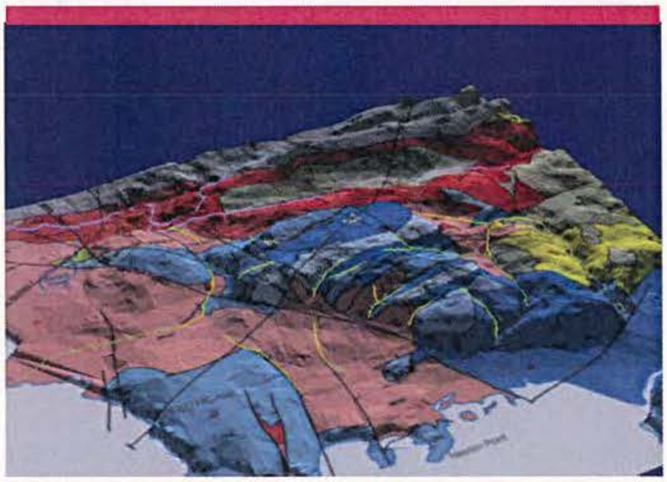
Lehmann, E.L. (1975) Nonparametrics: Statistical Methods Based on Ranks. San Francisco: Holden-Day, Inc.

WynThomasGordonLewis, 2004. Environment Act 1995: Review of Mineral Planning Permissions Cornelly Quarry Environmental Impact Assessment

Appendix D.1 Parameters for Climate Based Assessment Criteria at Each Site

To be completed after first annual review after formal adoption of WMP.

APPENDIX E
Flow Network Model (Appendix 7.3 from SLR, 2014)



Cornelly Group of Quarries: Transient Flow Network Model

Cornelly Group of Quarries: Transient Flow Network Model

Prepared for

Lafarge Tarmac Ltd
Millfields Road
Ettingshall
Wolverhampton
WV4 6JP

Report reference: 6227 Appendix 7.3, March 2014
Report status: Final

Confidential
Prepared by
ESI Ltd

New Zealand House, 160 Abbey Foregate, Shrewsbury, SY2 6FD, UK
Tel +44(0)1743 276100 Fax +44 (0)1743 248600 email info@esinternational.com
Registered office: New Zealand House, 160 Abbey Foregate, Shrewsbury, SY2 6FD. Registered in England and Wales, number 3212832

Cornelly Group of Quarries: Transient Flow Network Model

This report has been prepared by ESI Ltd. (ESI) in its professional capacity as soil and groundwater specialists, with reasonable skill, care and diligence within the agreed scope and terms of contract and taking account of the manpower and resources devoted to it by agreement with its client, and is provided by ESI solely for the internal use of its client.

The advice and opinions in this report should be read and relied on only in the context of the report as a whole, taking account of the terms of reference agreed with the client. The findings are based on the information made available to ESI at the date of the report (and will have been assumed to be correct) and on current UK standards, codes, technology and practices as at that time. They do not purport to include any manner of legal advice or opinion. New information or changes in conditions and regulatory requirements may occur in future, which will change the conclusions presented here.

This report is confidential to the client. The client may submit the report to regulatory bodies, where appropriate. Should the client wish to release this report to any other third party for that party's reliance, ESI may, by prior written agreement, agree to such release, provided that it is acknowledged that ESI accepts no responsibility of any nature to any third party to whom this report or any part thereof is made known. ESI accepts no responsibility for any loss or damage incurred as a result, and the third party does not acquire any rights whatsoever, contractual or otherwise, against ESI except as expressly agreed with ESI in writing.

Confidential
Prepared by
ESI Ltd

New Zealand House, 160 Abbey Foregate, Shrewsbury, SY2 6FD, UK
Tel +44(0)1743 276100 Fax +44 (0)1743 248600 email info@esinternational.com
Registered office: New Zealand House, 160 Abbey Foregate, Shrewsbury, SY2 6FD. Registered in England and Wales, number 3212832

TABLES

1 INTRODUCTION

This technical appendix describes the development, calibration and use of a transient flow network model which has been developed to support the assessment of the potential effects of the future development of the Connelly Group of Quarries on the local hydrology.

1.1 Background

In the first hydrogeological impact assessment report for Cornelly Quarry (ESI, 2004), a complex steady state "groundwater flow network model" was developed. The model was almost entirely designed to simulate bedrock groundwater flow with the exception of a cell representing the sand and gravel layer which lies beneath the Blown Sands at Kenfig.

Due to the limitations of the groundwater flow network model, additional detailed calculations were undertaken to determine the impact of changes in groundwater level and flow on the Blown Sand aquifers at Kenfig and Merthyr Mawr. The conclusions from these detailed calculations were as follows:

- At Kenfig: Drawdowns of between 4.6 and 6.1 m are required in the sands and gravels in order to induce an average 0.1 m change in head (the sensitivity threshold identified by CCW (now NRW)) in the dunes over the period.
- At Merthyr Mawr: Reduction in inflows from the north would need to be greater than 5% (probably around 10%) to induce a 0.1 m change in average summer groundwater level.

Subsequent discussions with NRW for the current phase of work have identified a need to assess transient aspects of dewatering at the Cornelly group of quarries (the rate at which the effects of a sudden increase in abstraction would transmit away from the quarries, the effects and duration of recovery at the end of pumping) and also an incorporation of the variation in hydrogeological conditions at Kenfig and Merthyr Mawr.

In order to do this it has been decided to adapt the existing groundwater flow network model to work in transient mode and also to directly simulate conditions at Kenfig and Merthyr Mawr through the incorporation of additional model cells. The updated model construction and results are described in the following sections.

1.2 Structure of this Document

The planning context etc. is described in the main Environmental Statement. The conceptual model on which the model is based is described in Appendix 7.1 of the Environmental Statement.

After this introduction, Section 2 describes the transient flow model in detail. Section 3 describes the model calibration whilst Section 4 explains how the predictive scenarios were set up. The results of the predictive scenarios are set out in Appendix 7.4.

6227 Appendix 7.3. Final

	Name	Signature	Date	Issued to
Author	Simon Arthur	S Arthur	04/03/14	Project Team
Checked by	Barnaby Harding	Barnaby Harding	04/03/14	Project Team
Reviewed by	Mike Streetly	M. J. Streetly	04/03/14	Project Team

Revision record:

Issue	Date	Status	Comment	Author	Checker	Reviewer
1	04/03/2014	Final		SRA	BCH	MJS
2						
3						
4						

Confidential
Prepared by
ESI Ltd

New Zealand House, 160 Abbey Foregate, Shrewsbury, SY2 6FD, UK
Tel +44(0)1743 276100 Fax +44 (0)1743 248600 email info@esinternational.com

FIGURES

ILLUSTRATIONS

CONTENTS

2 MODEL DESCRIPTION

2.1 Modelling Approach

The model has been developed as an Excel spreadsheet and VBA code, and designed to simulate daily time series for groundwater heads and discharges.

Modelling is undertaken using explicit timestepping and changes in groundwater levels in each zone are derived from recharge, from groundwater flows between connected zones and discharges to boundary conditions (either to springs, drains, dewatering abstractions or the sea).

2.2 Model Zones

Model zones were defined on the basis of the conceptual model (Appendix 7.1) and are broadly consistent with the areas represented in the steady state model undertaken in a previous assessment (ESI, 2004). These zones were further subdivided to represent the areas around the quarries (to allow a more accurate assessment of the quarry inflows and outflows) in addition to refinement and layering around Kenfig dunes and Merthyr Mawr.

A schematic representation of the model zones used in the simulations is shown on Figure 2.1 and is described in more detail in the following sections.

2.3 Recharge

The derivation of the recharge input for the model is described in the Conceptual Model Report (Appendix 7.1). It is based on the soil moisture balance approach previously used at Cornelly both for the conceptual model (Appendix 7.1) and for the water Management Plan (Climate based assessment criteria).

Daily recharge values in the model are spatially distributed between zones to correspond with the sites for which the recharge input calculations were undertaken (see some discussion on different areas in Appendix I of Appendix 7.1). The rate at which water allowed to recharge the groundwater system is therefore determined by the recharge values and the area of each model zone.

The change in groundwater flux due to recharge $\Delta Q_{rec,j}$ in each j'th zone at time t is calculated from:

$$\Delta Q_{rec,j} = (1 - \alpha_j).R_{j,t}.\mathrm{A}_j.$$

where $\propto$ is fractional runoff(-),

R is recharge (m/day),

A is the zone area (m^2)

When the quarry is restored to open water there is the potential that the rate of evaporation will be different from that assumed in the recharge model. The degree of difference is hard to quantify as, although (for equivalent climatic conditions) the evaporation rate from open water is typically higher than for grass (the assumption of the recharge model), the rate of potential evaporation is very dependent on sunshine, humidity and wind speed. In a deep, steep sided quarry it is very likely that sunshine and wind speed (which promote evaporation) will be lower and humidity (which reduces evaporation) will be higher. It is thus possible that the potential evaporation rate at the water surface will be lower than would be assumed by standard calculations.

However, in order to assess the potential significance of this uncertainty, the recharge model has been re-run in a way that simulates the effects of open water whilst ignoring the effect of the factors discussed above. The results of this model are as follows:

Recharge rate (grass)	822 mm/a (average for period 1993 To 2003)
Recharge rate (open water)	719 mm/a (average for period 1993 To 2003)

Difference 103 mm/a.

Applying this difference over the potential area of open water (~25 ha) suggests an equivalent abstraction rate of around 70 m3/d. This effective abstraction rate is very small relative to current and predicted dewatering rates in the quarry and is not likely to have any discernible effect on the regional groundwater flow system. On this basis it has not been considered further in the modelling.

2.4 Discharge

The model allows for discrete discharges (e.g. local abstractions) to be input as time series for each zone over the duration of the simulation. By default discharges are input as -ve. Water can also be added to each zone using +ve values. Change in groundwater flux in each j'th zone due to discrete discharges $\Delta Q_{dis,j}$ at time t is calculated from

$$\Delta Q_{dis,j} = D_{j,t}$$

where D is discharge at time t (m^3/day)

2.5 Connectivity

The connection of the groundwater system is modelled as a series of zones representing the saturated zone in the main formations in the area. The saturated zone acts to transfer groundwater down hydraulic gradient between each zone.

The total groundwater flow between each j'th zone from each i'th zone at time t ($\Delta Q_{\Sigma i,j}$) is calculated from:

$$\Delta Q_{\Sigma i,j} = \sum_{i=1}^{N_{zone}} (h_{t-1,j} - h_{t-1,i}).\frac{T_{i,j}.w_{i,j}}{x_{i,j}}$$

where $h_{t-1,j}$ is the groundwater head from the previous timestep (m),

$T_{i,j}$ is the transmissivity between each zone (m^2/day),

$w_{i,j}$ is the flow width (m),

$x_{i,j}$ is the flow distance (m).

As more than one geology type may be described between nodal points and each flow path, the transmissivities are calculated using a harmonic mean approach (see Illustration 2.1).

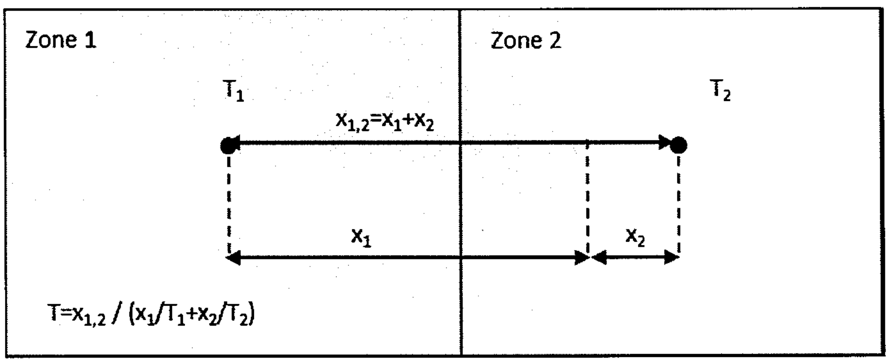


Illustration 2.1 Calculation of bulk transmissivity

The resulting transmissivity between each i'th and j'th zone is defined as:

$$T_{i,j} = x_{i,j} \;/\; \sum_{k=1}^{N_{trans}} \frac{x_k}{T_k}$$

where $x_{i,j}$ is the distance between zones (m),

x_k is the distance across a particular geology type (m),

T_k is the transmissivity of a particular geology type (m^2/day),

Parameterisation of the transmissivity of individual formations is discussed in Section 3.3.

2.5.1 Variation of hydraulic conductivity with depth (VKD)

An additional complication in the estimation of transmissivity is the concept of variable hydraulic conductivity with depth (or VKD). This is consistent with both the description of palaeokarst in the area (Appendix H of Appendix 7.1) and a review of the groundwater level information (see Section 3.3.2). The implementation of the VKD element in the model comprises up to three distinct hydraulic conductivity layers (see Illustration 2.3).

If deemed appropriate, transmissivity between each zone can be replaced with the VKD representation. VKD is recalculated at the beginning of each timestep using the previous estimates of groundwater head. Parameterisation of this feature is set out in Section 3.3.2.

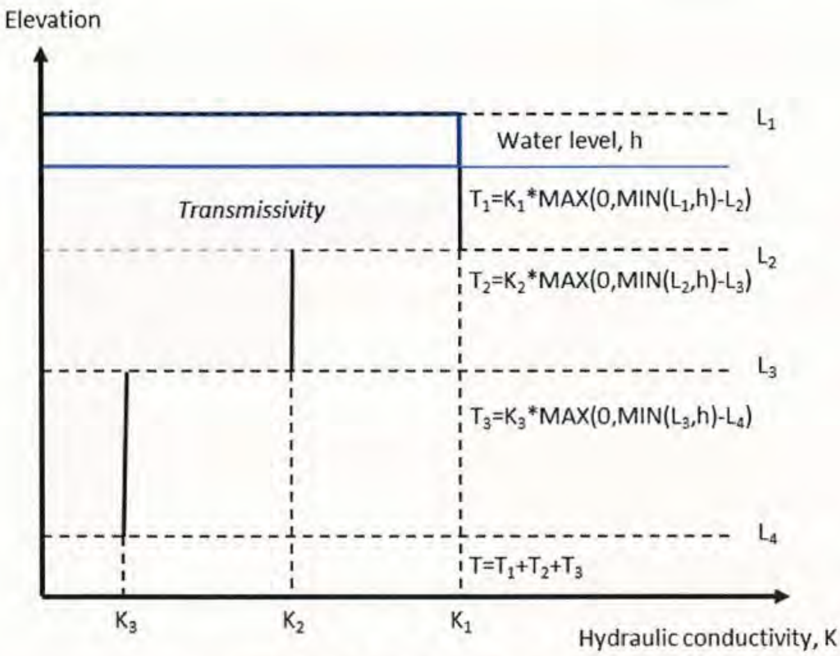


Illustration 2.2 Calculation of VKD

2.5.2 Vertical flow

The model allows for the incorporation of intervening layers between model zones (to represent a low hydraulic conductivity layer such as till for example). These intervening layers are not explicitly modelled (they are not a zone for which a groundwater head is computed).

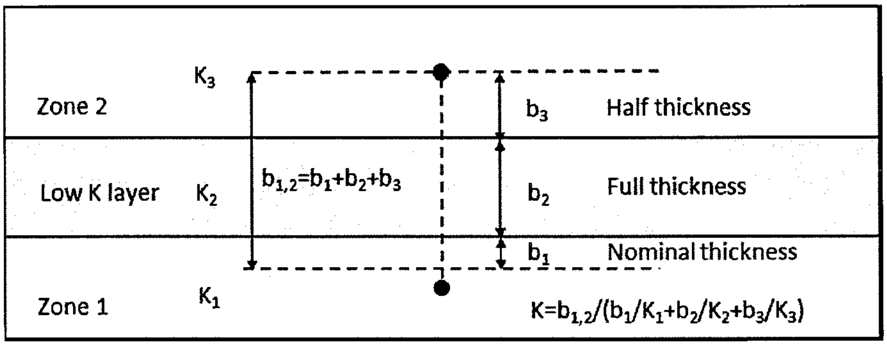


Illustration 2.3 Calculation of vertical hydraulic conductivity

The resulting hydraulic conductivity is calculated using the harmonic mean (see Illustration 2.3). This is calculated using a nominal thickness of the bottom layer (1m), the full thickness of the intervening layer and the half thickness of the overlying layer.

$$K_{\mathrm{ver,i,j}} = \mathrm{b}_{i,j} \;/\; \sum_{k=1}^{N_{cond}} \frac{b_k}{K_k}$$

where $K_{\mathrm{ver,i,j}}$ is the vertical hydraulic conductivity between zones (m/day),

$\mathrm{b}_{i,j}$ is the distance between zones (m),

b_k is the distance across a particular layer (m),

K_k is the vertical hydraulic conductivity of the k'th layer (m/day),

Apart from the interaction between these cells being vertical, the mathematics is similar as for the other cells. Vertical flow $\Delta Q_{ver,i,j}$ is calculated as:

$$\Delta Q_{ver,i,j} = (h_{t-1,j} - h_{t-1,i}).\frac{K_{ver,j}.A_j}{b_j}$$

where $h_{t-1,j}$ is the groundwater head from the previous timestep (m),

b_j is the thickness between zones (m).

2.6 Boundary Conditions

2.6.1 General head boundary

Discharges to downstream boundaries, such as the sea, are simulated using a general head boundary. The change in groundwater flow in each jth zone due to flow to the general head boundaries ($\Delta Q_{ghb,j}$) are determined using:

$$\Delta Q_{ghb,j} = -(h_{t-1,j} - h_{ghb,j}).\frac{T_{ghb,j}.w_{ghb,j}}{x_{ghb,j}}$$

where $h_{ghb,,j}$ is the head assigned as the boundary value in each zone(m),

$T_{ghb,j}$ is transmissivity along the flow path to the general head boundary (m^2/day),

$w_{ghb,j}$is the width along the flow path to the general head boundary (m),

$x_{ghb,j}$ is the distance to the general head boundary (m).

2.6.2 Spring

A similar expression can be used to represent spring flows, although discharge is subject to a head constraint. The spring is only active if the heads exceed the spring elevation. Spring discharge $\Delta Q_{spr,j}$ from each j'th zone are determined using:

$$\Delta Q_{spr,j} = (h_{t-1,j} - h_{spr,j}).\frac{T_{spr,j}.w_{spr,j}}{x_{spr,j}} \qquad if\ h_{t-1,j} > h_{spr,j}$$

$$\Delta Q_{spr,j} = 0 \qquad if\ h_{t-1,j} \leq h_{spr,j}$$

where $h_{spr,,j}$ is the head assigned as the spring boundary value in each zone(m),

$T_{spr,j}$ is transmissivity along the flow path to the spring (m²/day),

$w_{spr,j}$is the width along the flow path to the spring (m),

$x_{spr,j}$ is the distance to the spring (m).

Spring transmissivity can be specified using a fixed value, or use dynamic values calculated using VKD.

2.6.3 Drain

The drain boundary condition is used to simulate overtopping, for example where Kenfig Pool has been observed to overtop and flow westwards into the dune slacks during periods of high groundwater levels.

A volume of water in a store above drain elevation $\Delta Q_{dra,j}$ is removed from the model as drain flow.

$$\Delta Q_{dra,j} = -(h_{t-1,j} - h_{dra,j}).A_j.S_j/\Delta t \qquad if\ h_{t-1,j} > h_{dra,j}$$

$$\Delta Q_{dra,j} = 0 \qquad if\ h_{t-1,j} \leq h_{dra,j}$$

2.6.4 Sump

Flow calculations were modified in the vicinity of the quarries, where the mass balance equations do not take into account radial flow. A tractable approach is to use the analytical equation of unconfined radial flow to a well. Flow is established from the head difference at two radial distances from the sump. If we assume that these heads (sump levels and head at a given radius from the sump) are constant over one timestep the flow field will be radial. Under this assumption, radial flow through any 'cylinder' must be identical to the sump dewatering rate $\Delta Q_{sum,j}$. This is effectively the unconfined Thiem-Dupuit radial flow equation for groundwater flow toward the pumping wells:

$$\Delta Q_{sum,j} = \frac{\pi.K_{h,j}.((h_{t-1,j} - b_j)^2 - (s_{t-1,j} - b_j)^2)}{2.3.\log(r_{h,j}/r_{s,j})}$$

where h_j and s_j are the zone and sump head respectively (m),

$r_{h,j}$ and $r_{s,j}$ are the zone and sump radius respectively (m),

b_j is the base of the aquifer (m),

$K_{h,j}$is the horizontal hydraulic conductivity (m/day),

The sump head represents the dewatered level (the sump level) within the quarry itself (considered to extend 10 m below the base of the lowest working bench level) provided as a time series representing the quarry development. The zone head is representative of groundwater heads at a given radius outside of the immediate quarry boundaries, calculated for each zone in which active dewatering is occurring.

Hydraulic conductivity was limited to the zone of active aquifer in the vicinity of the quarry sump (up to the zone groundwater water level predicted by the model). This assumes that most of the groundwater inflow to the quarry sump occurs laterally rather than vertically. Depth dependent hydraulic conductivity can be accounted for by simple averaging.

2.6.5 Boundary condition re-direction

All spring, drain and sump flows can be routed to discharge to other model zones. For example, to simulate pumping from quarries, or discharge from springs into other areas. The discharge ΔQ_{red} is implemented at each timestep using spring, drain or sump flows from the preceding timestep.

Flows can be redistributed according to fixed proportions (i.e. part of each flow can be redistributed to more than one zone). The model also allows flows to be redistributed according to a series of logic statements. The logic statements work in combination with the concept of 'additional storage' (see Section 2.8) in which redirection to several zones can be simulated based on the volume of the additional storage.

2.7 Change in Storage

For each zone, the resulting change in storage is calculated from the sum of all inflows and outflows for each zone as:

$$\Delta Q_{sto} = \Delta Q_{rec} + \Delta Q_{dis} + \Delta Q_{\Sigma i,j} + \Delta Q_{ver} + \Delta Q_{ghb} + \Delta Q_{spr} + \Delta Q_{dra} + \Delta Q_{sum} + \Delta Q_{red}$$

2.8 Additional Storage

There are a number of features in the model area that may potentially contain significant volumes of water and may locally affect heads. For example, part of each model zone may include settlement lagoons, dune slacks and pools that may contribute to additional storage. This additional storage volume may also become active only when groundwater levels rise above a particular elevation (for example the sump level, or base of pool).

An additional storage area can be incorporate within each zone as shown in Illustration 2.4.

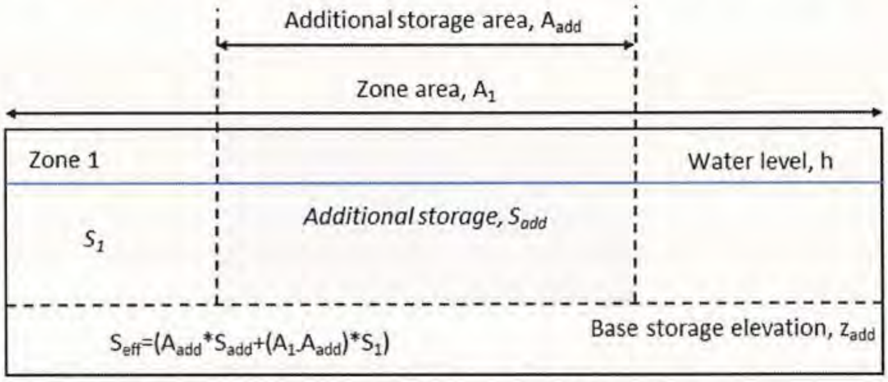


Illustration 2.4 Calculation of additional storage

The user needs to specify an additional storage area, the value of additional storage (i.e. 1.0 for open water) and the elevation above which this additional storage becomes active. Groundwater levels within each zone are still assumed to be constant and an effective storage $S_{eff,j}$. for each zone can be calculated when the set elevation is exceeded:

$$S_{eff,j} = (S_j(A_j - A_{add,j}) + S_{add,j}A_{add,j})/A_j \qquad if\ h_{t-1,j} > z_{add,j}$$

$$S_{eff,j} = S_j \qquad if\ h_{t-1,j} \leq z_{add,j}$$

where $S_{add,j}$ is the additional storage (-),

$A_{add,j}$ is additional storage area (m^2).

2.9 Change in Groundwater Head

Following changes in storage from the sum of all inflows and outflows in each zone there is a response in groundwater levels. For each j'th catchment store the change in groundwater head (Δh_j) at time t is calculated from:

$$\Delta h_j = {\Delta Q_{sto,j}}/{S_{eff,j}.A_j}.\Delta t$$

The new head at time t is therefore:

$$h_t = h_{t-1} + \Delta h$$

2.10 Model Geometry

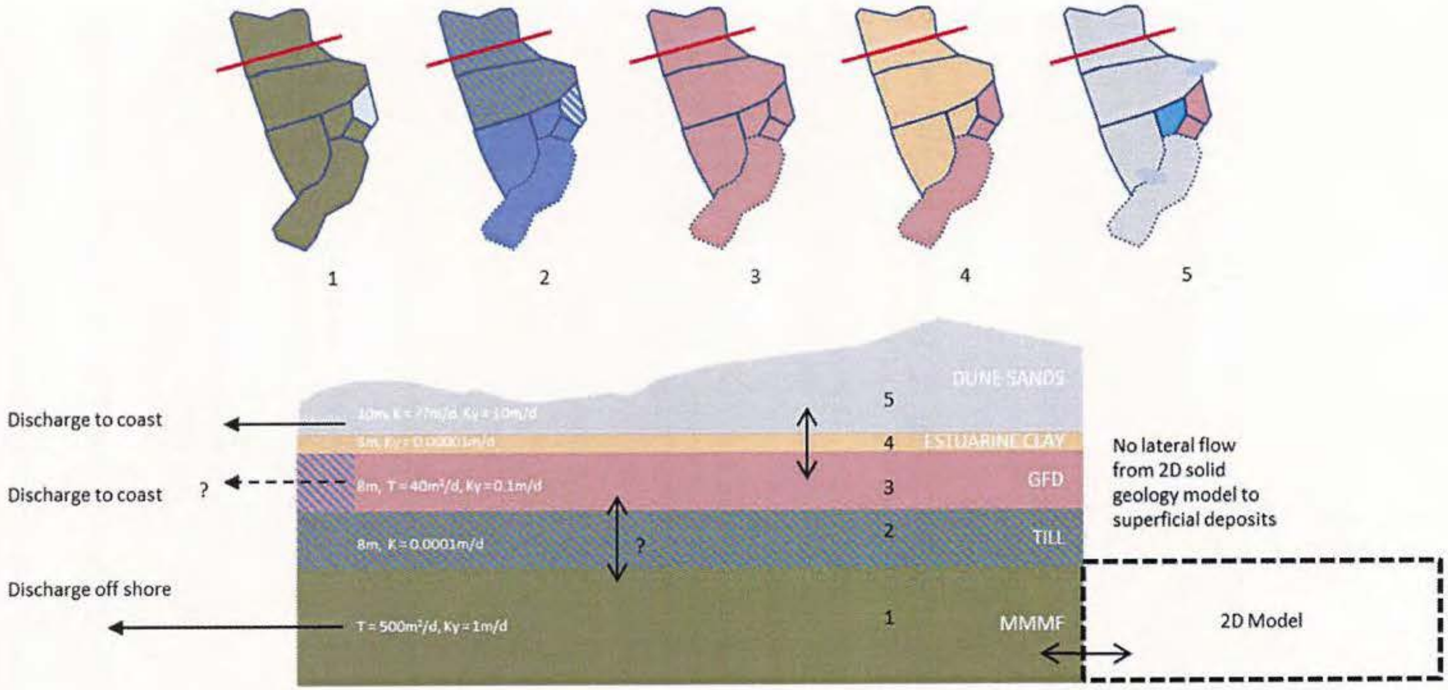
In order to address some of the concerns raised in previous consultations, the sand dunes in Kenfig and Merthyr Mawr have been explicitly represented in this model. Using the layered model the groundwater flow network model can be used directly to assess potential effects of additional quarry development on water levels within the dune systems. This required the addition of model cells at a scale appropriate to model potential impacts that effectively overlie the cells representing the 'solid' geology.

2.10.1 Kenfig

The conceptual model of the layered system at Kenfig is discussed in detail in the conceptual model report (Appendix 7.1) and can be broadly summarised as:

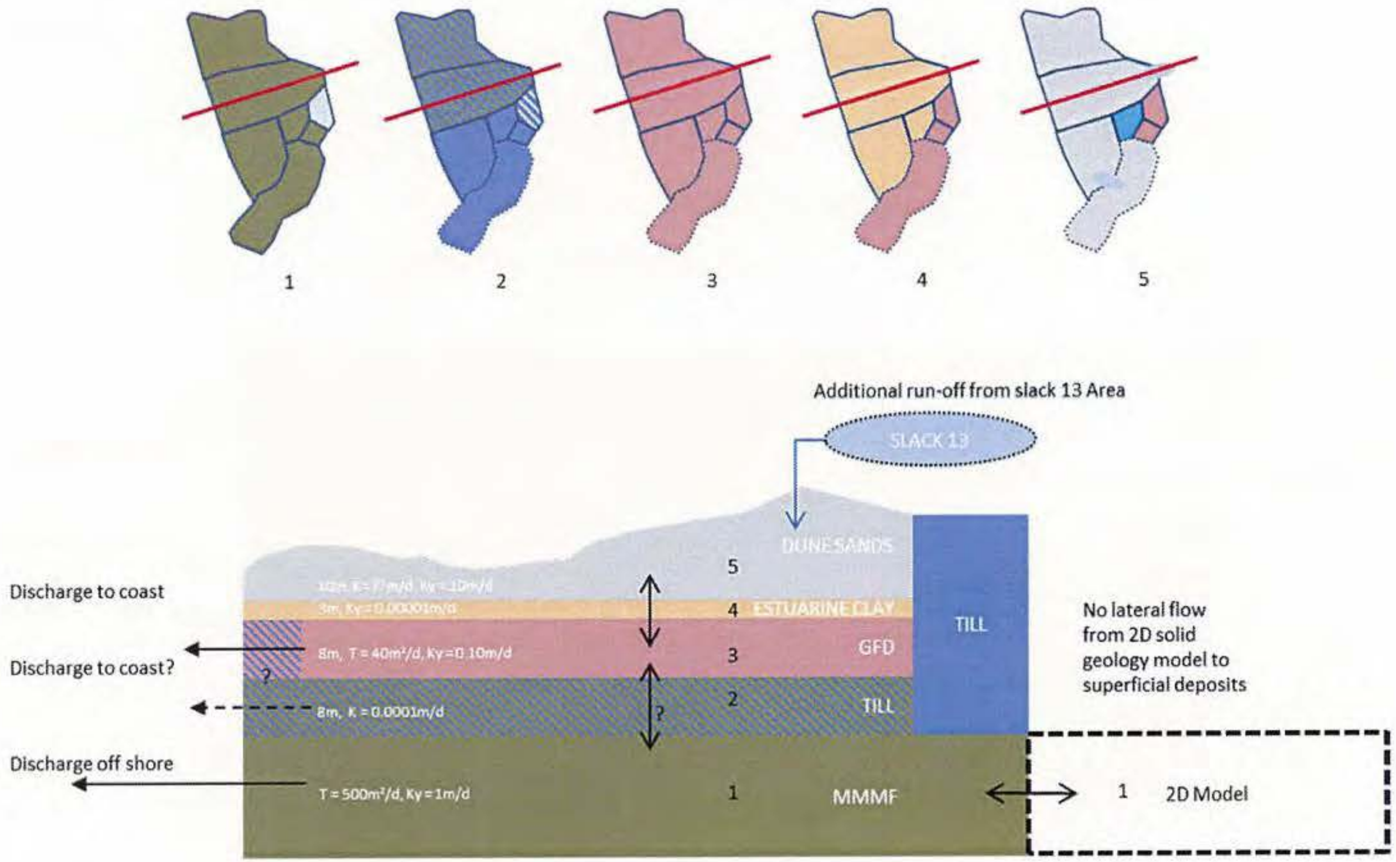
- The blown sand act as a fairly homogeneous system. They are fed by direct rainfall and discharge occurs laterally via groundwater flow to the coast and, to a lesser extent, via downwards leakage into the underlying geology;
- A series of glaciofluvial sands and gravels underlie the blown sand. Groundwater levels are generally lower and show distinctly different behaviour. This is believed to be due to an extensive intervening layer of low hydraulic conductivity estuarine clay that limits the connection between the dunes and the underlying sands and gravels;
- The extent of the estuarine clay underlying the blown sand and Kenfig Pool is uncertain;
- Glaciofluvial sands and gravels underlying the estuarine clay are fed by recharge in the area of outcrop (east of Kenfig Pool), groundwater flow (from potentially well-connected underlying geology) and leakage from the overlying formations;
- The glaciofluvial deposits/till around Borehole A acts as a minor, perched aquifer to feed the ephemeral springs that flow to Kenfig Pool.
- The glaciofluvial system is not well connected to the underlying 'solid geology' groundwater flow system around the south of the pool but appears to be in closer connection to the north east (borehole N).
- A low hydraulic conductivity till limits the connection between the sands and gravels and underlying solid geology, although the extent of this till layer is not certain. Connection between the sands and gravels and the coast may also be restricted by this till layer;
- Kenfig pool may receive some ephemeral inflows from seeps to the east. At high water levels the pool overflows to the south west.

Schematic illustrations of the Kenfig dune system demonstrating the model connectivity (and conceptual uncertainty in these connections) are shown in Illustration 2.5 to Illustration 2.12 below.



? Uncertainty in connections form sensitivity analysis

Illustration 2.5 Kenfig model section 1



? Uncertainty in connections form sensitivity analysis

Illustration 2.6 Kenfig model section 2

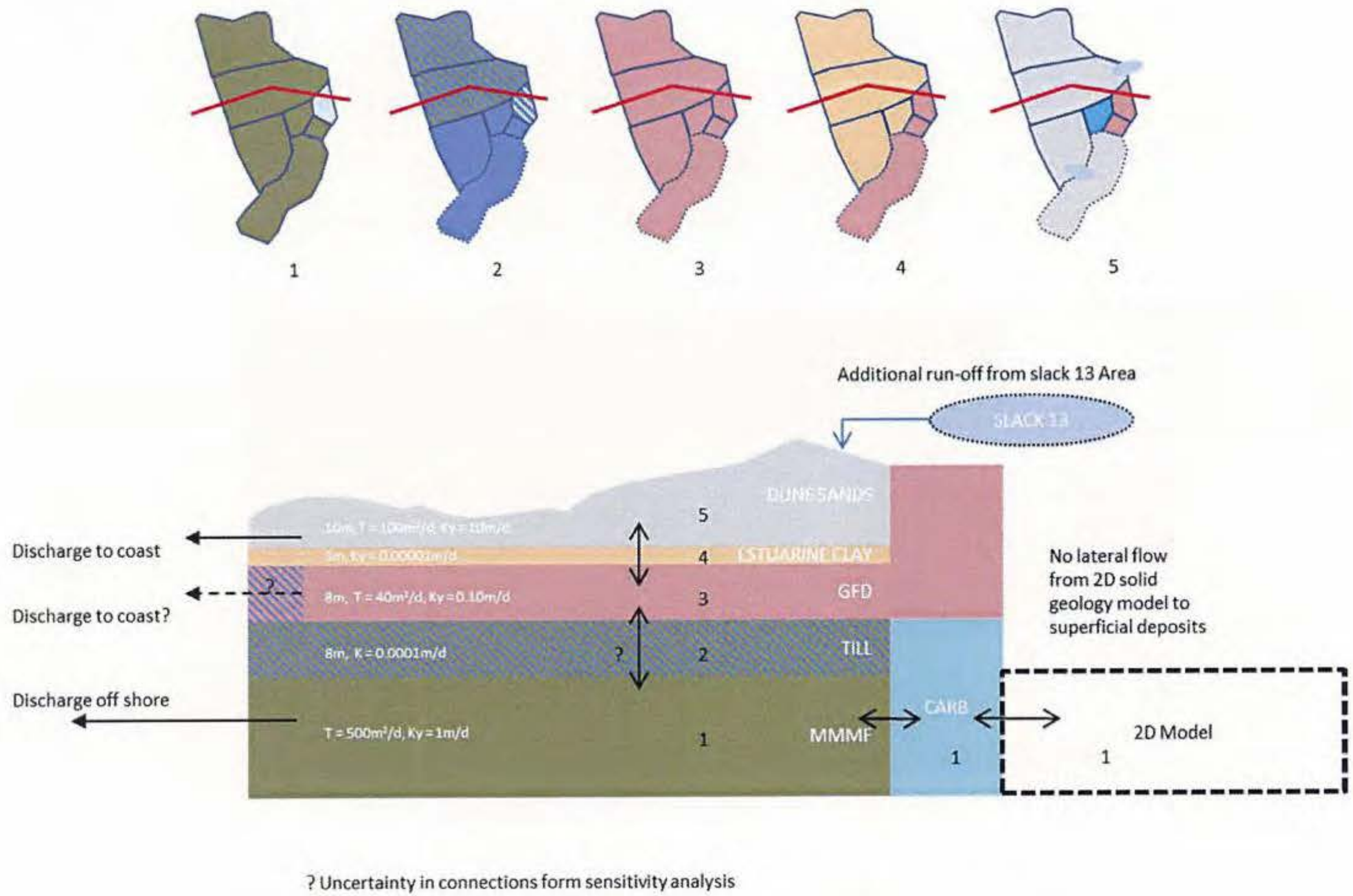


Illustration 2.7 Kenfig model section 3

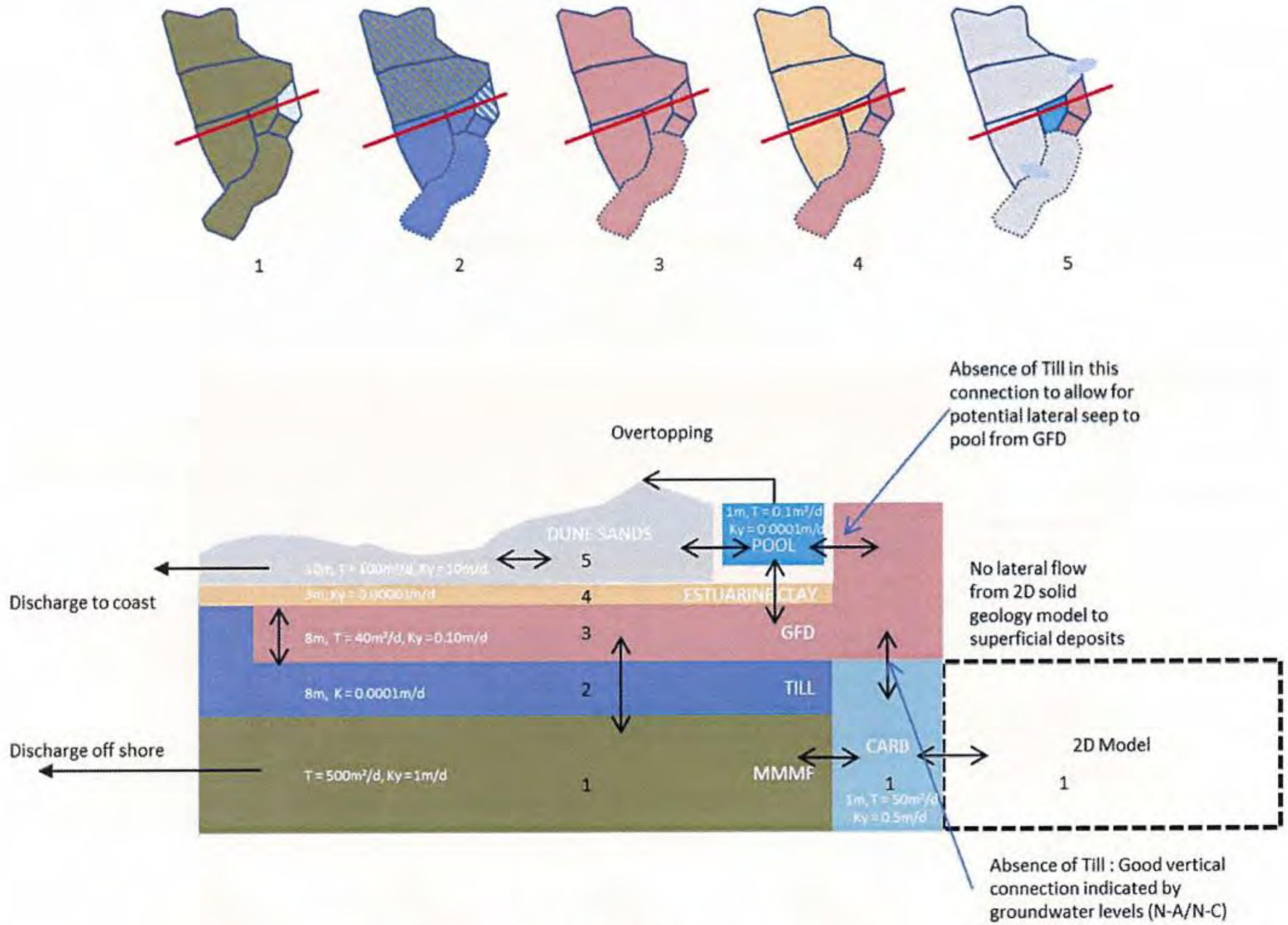


Illustration 2.8 Kenfig model section 4

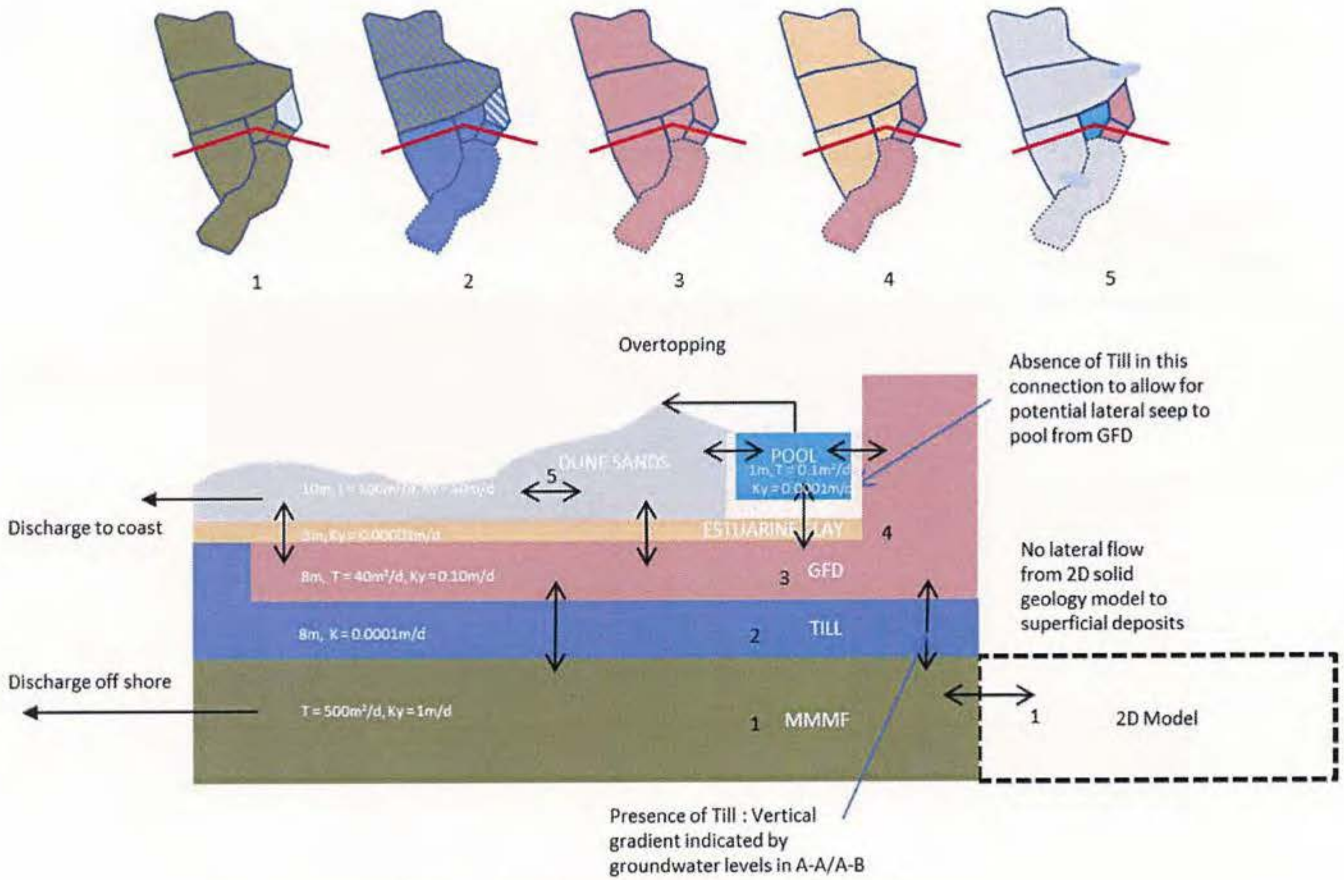


Illustration 2.9 Kenfig model section 5

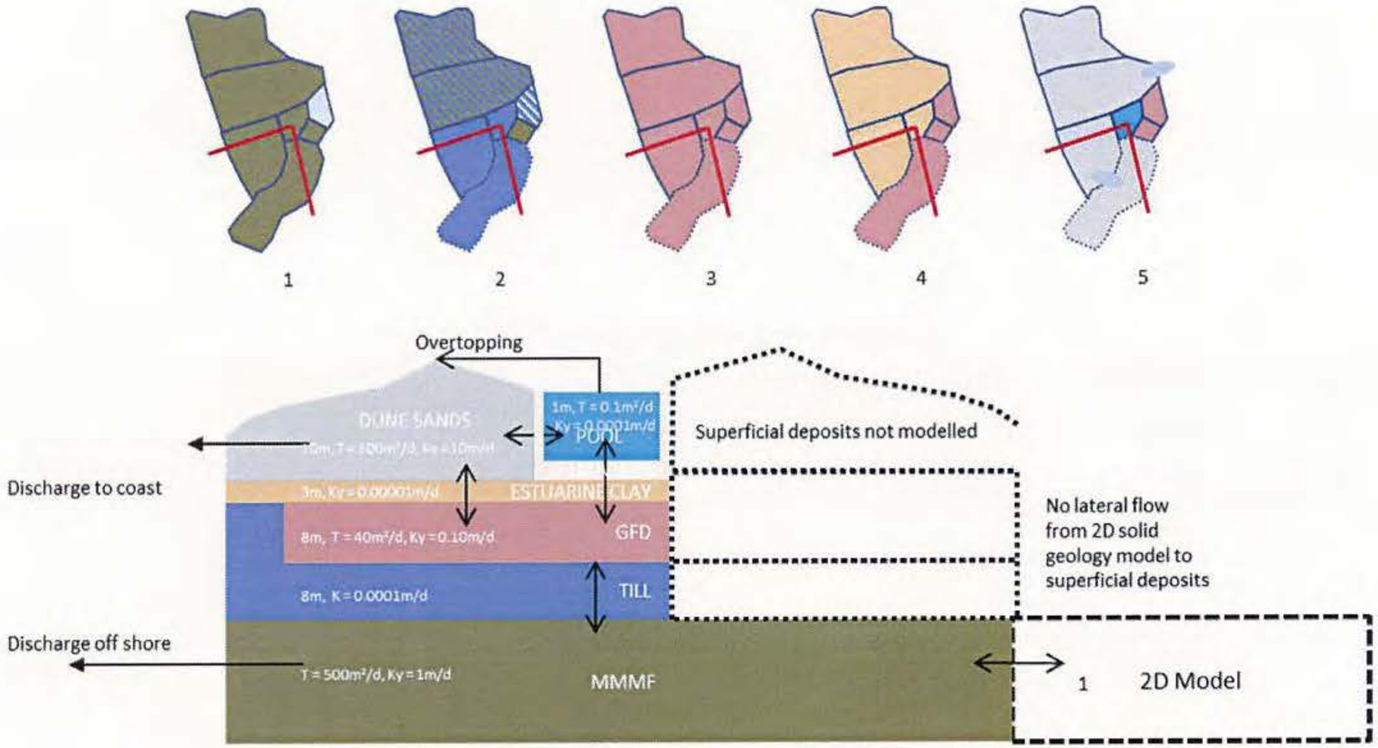


Illustration 2.10 Kenfig model section 6

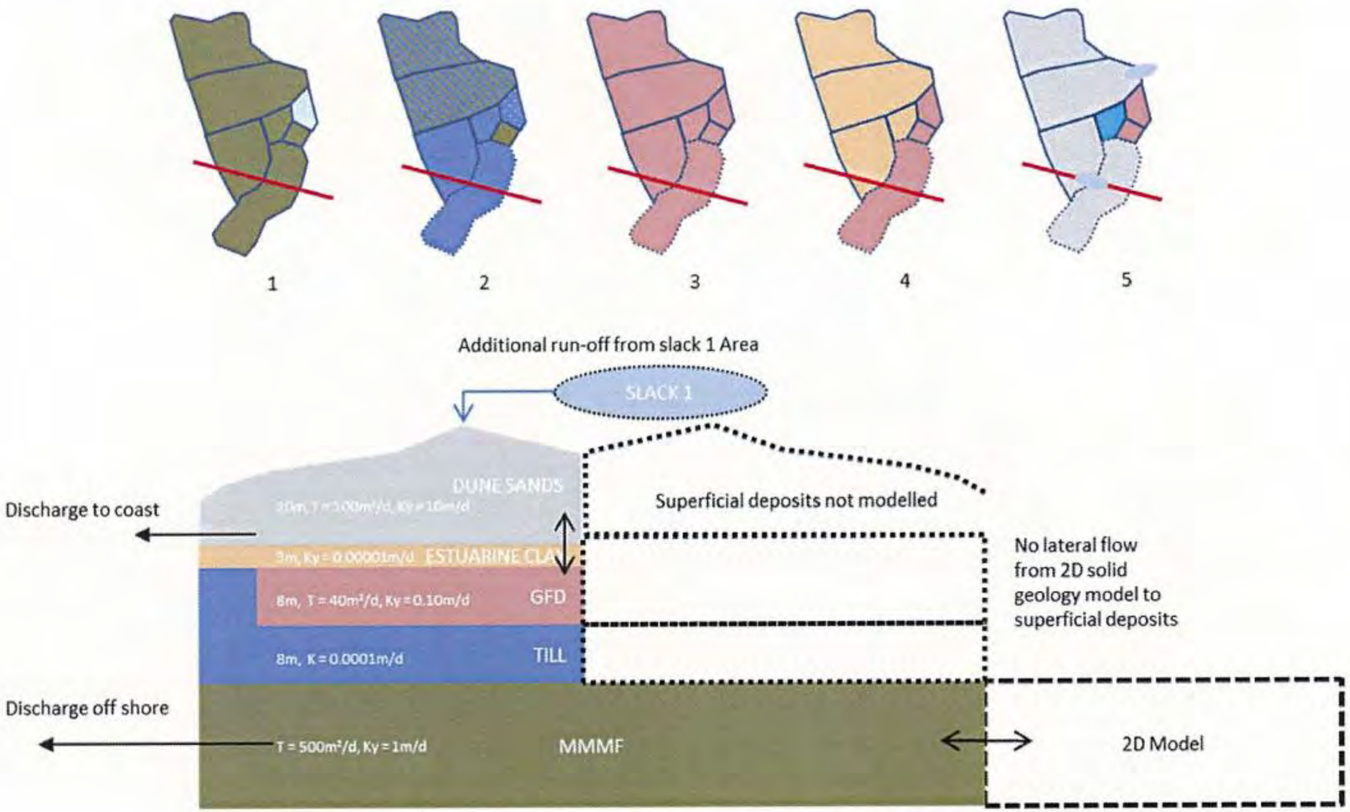
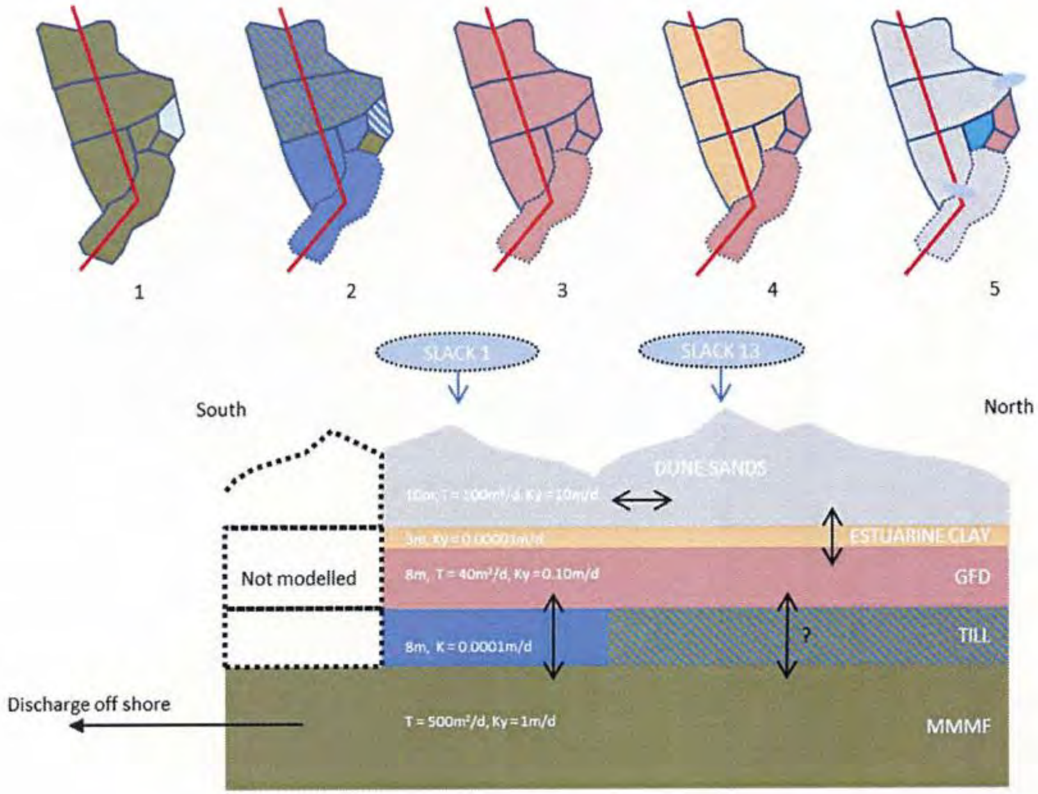


Illustration 2.11 Kenfig model section 7



? Uncertainty in connections form sensitivity analysis

Illustration 2.12 Kenfig model section 8

2.10.2 Merthyr Mawr

The conceptual model at Merthyr Mawr is discussed in detail in the conceptual model report (Appendix 7.1) and can be broadly summarised as:

- The blown sand receive direct recharge groundwater inflow from the Carboniferous Limestone (Burrows Well).
- Discharge in the blown sand occurs laterally via groundwater flow and overland via series of pool and dune slacks to the coast.
- Discharge in the blown sand also occurs via downwards leakage. Connection between the dunes and the underlying limestone is via an extensive but thin (1 m) underlying clay layer;
- South of Burrows Well, water levels are affected by the discharge of limestone groundwater levels into the blown sand which causes large areas to pond.
- When the spring stops flowing, these water levels drop rapidly and the groundwater system in this area is not typical of dune slacks more generally. SWS, 2010 suggest that this area may be perched on a thin clay layer.
- Groundwater gradients are locally predominantly downwards from the blown sand to limestone.

A schematic illustration of the Merthyr Mawr dune system demonstrating the model connectivity is shown below.

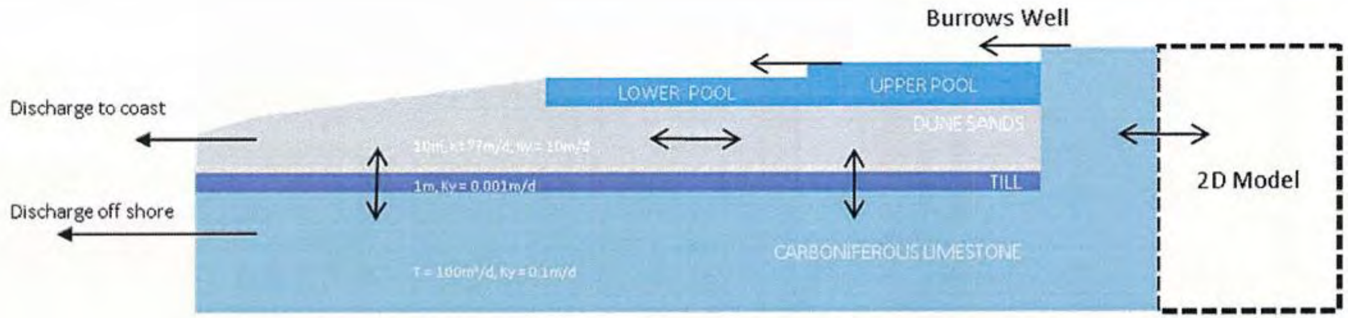


Illustration 2.13 Merthyr Mawr model section 1

3 MODEL CALIBRATION

3.1 Calibration Targets

The purpose of model calibration is to adjust certain model parameters (transmissivity, storage, etc.) within credible ranges in order to derive a close correlation between observed and simulated conditions. In this case, the model has been calibrated to the following targets:

- observed groundwater levels (including assessment of likely groundwater levels at Cornelly prior to the start of dewatering),
- observed flows at New Mill Farm springs,
- observed flows at Burrows Well, and
- dewatering flows from within Cornelly quarry

Location of the calibration targets are shown in Figure 3.1.

3.1.1 Groundwater level targets

Thirty-two observation boreholes (summarised in Table 3.1) were selected as targets across the model area. Calibration targets were selected on the basis of location (ideally as close as possible to the centre of each zone), record length, frequency of measurement and perceived quality of the data.

Table 3.1 Calibration head targets

Borehole	X	Y	Count	From	To	Zone
TQ3	283070	179881	1662	16/06/1995	12/06/2013	1
ESP2	283025	179725	117	26/04/1999	18/01/2009	2
TM6	283905	179854	211	31/10/1994	12/06/2013	3/4
TM4	283718	180395	1566	08/11/1992	18/08/1999	5
RWC107	282883	179954	226	20/08/1998	07/06/2013	8
RWC105	282658	179886	163	20/08/1998	07/06/2013	9/18
G	284792	179502	122	17/10/2001	10/06/2013	10/20
T95/01	284304	179947	4235	22/09/1995	10/06/2013	11
T95/04	284099	180400	53	22/09/1995	27/11/2002	12
Q	282817	180984	102	22/10/2002	23/05/2013	14
E	282887	180499	118	25/03/2002	14/06/2013	15
17B	282137	180760	111	25/03/2002	23/05/2013	23
EASC	281757	180249	4876	20/04/1995	04/03/2012	24
N-A	280047	181714	100	02/12/2002	26/06/2013	25
RWC100	282187	179831	2345	12/08/1998	24/06/2010	26/27
40	281970	179600	118	24/04/2002	04/06/2013	28
ITUSCA	285104	178646	53	29/01/1998	22/05/2003	29
T	283825	179196	14	03/10/2012	02/10/2013	30
MM1	285602	176878	692	24/11/2009	14/10/2011	33
P	281848	181099	108	22/10/2002	27/06/2013	35
O-A	280473	182851	111	22/10/2002	05/06/2013	36
A-A	280206	181254	298	17/10/2001	12/06/2013	38
B-A	280564	180567	122	17/10/2001	04/06/2013	40
21	283050	178200	48	25/03/2002	24/01/2006	41
L	285059	177372	101	20/05/2001	10/06/2013	42/44
D7	285821	176834	71	01/03/2004	01/07/2013	43
D4	286253	176607	102	01/03/2004	01/07/2013	45
N-C	280047	181714	99	02/12/2002	26/06/2013	46
A-B	280206	181254	103	17/10/2001	12/06/2013	47
KP	279549	181172	4259	16/03/1999	30/11/2010	48/53
K1A	279348	181594	104	15/04/2003	26/06/2013	50
K1B	279348	181594	101	15/04/2003	26/06/2013	55
CC5	279202	182061	501	17/01/1986	01/06/2013	56

3.1.2 Spring flow targets

Location and available data for spring flow targets are summarised in Table 3.2.

Table 3.2 Spring flow calibration targets

Borehole	Location	X	Y	Count	From	To	Zone
Burrows Well		285650	177260	1596	02/01/2008	31/03/2013	32
New Mills Farm	HL9A2 HL9B	280638 280286	182941 182919	18	15/05/2002	06/06/2004	36

New Mills farm

No reliable continuous gauging data are available at New Mills Farm springs due to a combination of unstable river banks and irregular flooding from the Afon Kenfig (Appendix J of Appendix 7.1). Data available in December 2002 recorded a relatively constant flow of between 60 and 80 l/s, although the period of data recording is insufficient for the purposes of model calibration.

A limited number of spot flow measurements are available to estimate longer term flows at New Mills Farm Spring. The difference in spot gauging between HL9A2 (upstream) and HL9B (downstream) represents a 400 m reach along Afon Kenfig. These data are used to provide a general assessment of the magnitude of the flows at New Mills Farm. Clearly the use of this spot gauging also means that the total flow includes contributions from both sides of the reach and the limited data means that continuous and long term flows are not well constrained.

Table 3.3 Spot gauging data at New Mills Farm spring

	Spot gauging (HL9B-HL9A2)	
Date	l/s	m^3/day
15/05/2002	121	10454
10/06/2002	531	45904
11/07/2002	72	623
29/08/2002	135	11638
10/01/2003	317	27363
12/02/2003	235	20293
12/03/2003	389	33610
22/04/2003	95	8199
03/06/2003	268	23121
08/07/2003	101	8726
28/10/2003	98	8476
23/12/2003	120	10368
30/01/2004	175	15120
24/02/2004	251	21686
11/03/2004	235	20304
26/04/2004	250	21600
18/05/2004	62	5357
09/06/2004	32	2765

Burrows Well

A stream flow logger was installed on Burrows Well in January 2008 and continuous gauged flow data are available to March 2013. The available data are shown on Illustration 3.1.

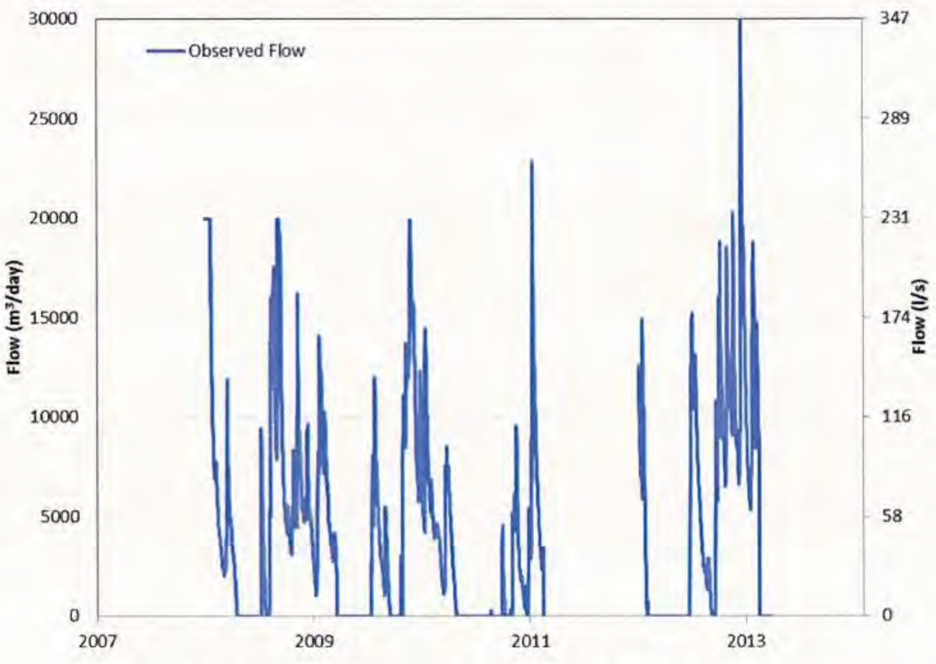


Illustration 3.1 Observed flow at Burrows Well

3.1.3 Pumping data

Cornelly Quarry is dewatered by pumping from a sump in the quarry floor to a settlement lagoon. In the past water has been pumped to Pant Mawr (and occasionally to Stormy Down), but currently water is pumped to Grove Quarry where water re infiltrates into the Carboniferous Limestone aquifer by seepage through the floor and sides of the flooded quarry.

Pumping data are available from June 2001 (Appendix N of Appendix 7.1), although the continuity and quality of the pumping records varies. Average pumping rates are summarised for different periods in Table 3.4 below.

Table 3.4 Average pumping rates at Cornelly quarry

Period	Sump	Offsite[1]	Comment
20 Jun 01 to 1 June 04	4873	1980	1202 m^3/d to Pant Mawr and 778 m^3/d to Grove
1 June 04 to 1 Oct 06	3382	1245	All to Grove from June 2004 to October 2006
1 Oct 06 and 5 Aug 08	-	2281	Assuming meter continued to run throughout
5 Aug 08 to 2 Jun 11	3735	2232	Since new meters installed
20 June 11 to 25 Mar 12	2969	2041	Since start of monitoring

[1] offsite excludes any re-circulation in the quarry itself

A complete record of inflow to Cornelly quarry has been reconstructed from the available data for the calibration period and is shown on Illustration 3.2 below. Note that the red line on this figure shows the average pumping rates for the periods where the quality of the monitoring data is considered to be reliable. Prior to available records (2001), estimates of the pumping rates have been made based on the available summary of dewatering activities at the quarry (Appendix N of Appendix 7.1). Net discharges to the lagoon and discharges offsite have also been calculated as part of the calibration process and are shown on

Illustration 3.3. Net discharges form explicit timeseries and are used as model input in respective model zones as discussed in Section 2.4.

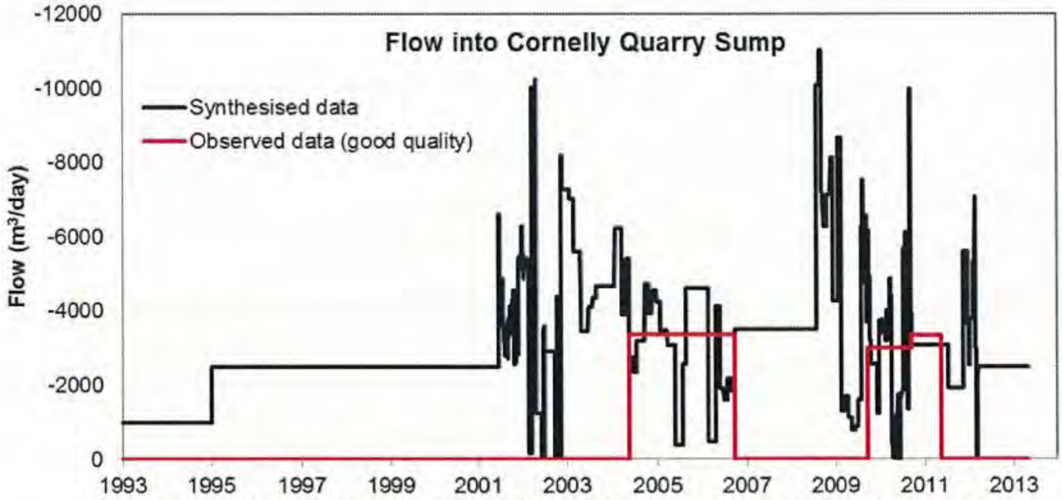


Illustration 3.2 Cornelly sump discharges used in model calibration

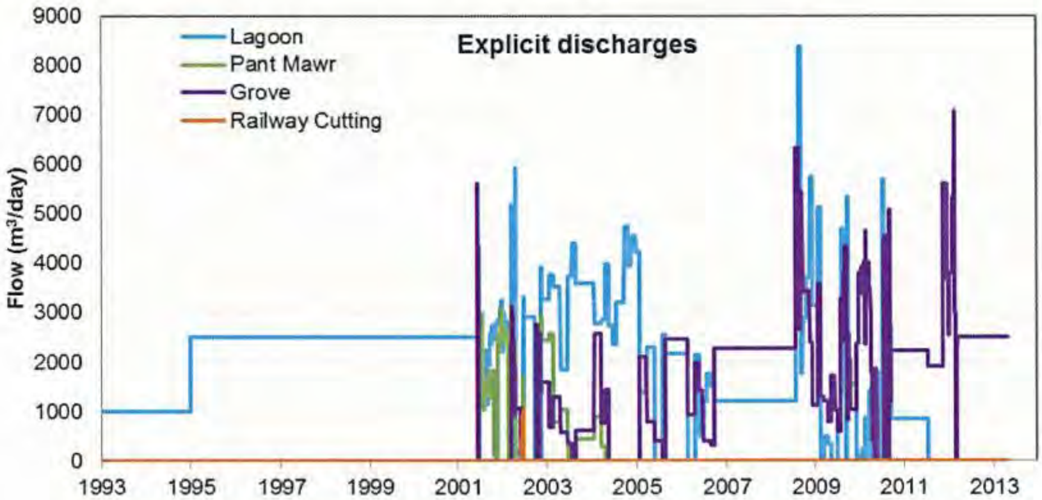


Illustration 3.3 Explicit discharges used in model calibration

Calibration of the inflows into Cornelly quarry is undertaken by using a history of development depths (see Illustration 3.4). Sump inflows are calculated from the development depths (Section 2.6) and compared to the observed (and synthesised) pumping rates from Cornelly sump. Clearly, data at different stages are more reliable than others, both due to uncertainty in the specified development depths and the reliability of the historical pumping data. Those data considered to be the more reliable data are shown on Illustration 3.2 and summarised in Table 3.5 below.

Table 3.5 Reliable pumping rates at Cornelly quarry

Period	Sump (m^3/day)
1 June 04 to 1 Oct 06	3382
5 Aug 08 to 2 Jun 11	3735

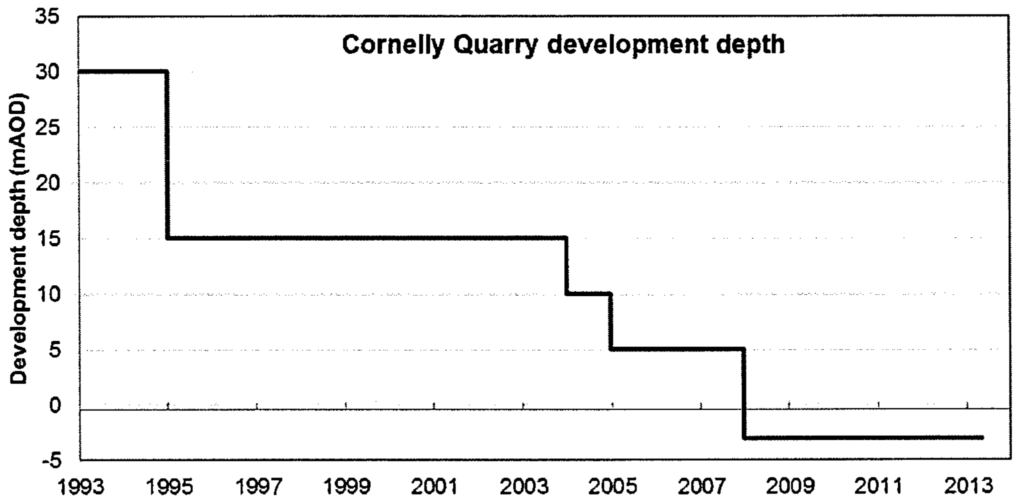


Illustration 3.4 Cornelly Quarry development depths

3.2 Initial Conditions

At the start of the simulation groundwater levels are set at an initial value using the average of field-measured head values (or interpolated values where no observation data are available for a given zone). These heads are not necessarily going to represent the groundwater system at equilibrium and response in the early time steps reflect the model under stress. The model requires some time to establish correct groundwater heads and flow (typically a period of one or two years from the start of the simulation is sufficient for the outputs to become reliable).

Initial heads used in the calibrated model in each zone are summarised in Table 3.6.

Table 3.6 Initial heads

Zone	Head	Zone	Head	Zone	Head	Zone	Head
1	42.0	16	24.0	31	16.0	46	10.2
2	34.0	17	24.0	32	12.0	47	10.8
3	60.0	18	24.0	33	5.0	48	9.7
4	60.0	19	22.0	34	20.0	49	9.0
5	60.0	20	64.0	35	22.0	50	8.4
6	57.0	21	64.0	36	8.0	51	8.6
7	57.0	22	50.0	37	6.0	52	8.3
8	39.0	23	23.0	38	9.0	53	10.4
9	34.0	24	15.0	39	12.0	54	10.0
10	60.0	25	10.0	40	10.0	55	9.0
11	56.0	26	5.0	41	6.0	56	10.3
12	58.0	27	17.0	42	12.9	57	9.9
13	31.0	28	9.5	43	8.5	-	-
14	31.0	29	61.0	44	6.1	-	-
15	24.0	30	13.8	45	8.3	-	-

3.3 Transmissivity

Groundwater flow between adjacent cells is a function of the transmissivity along the flow paths (a product of hydraulic conductivity and saturated thickness). Transmissivity is described by both geology considered to have constant transmissivities and those for which transmissivity varies as a function of the saturated thickness.

3.3.1 Fixed transmissivity

Solid geology

The final calibrated values of transmissivity for the solid geology are shown in Table 3.7. Values estimated during the development of the steady state model (ESI, 2003) are also shown for comparison.

Table 3.7 Calibrated transmissivity values for solid geology

Geology	Model transmissivity (m^2/day)		Zone
	Transient	Steady state	
Carboniferous limestone	see Table 3.9	n/a	1-33
Mercia Mudstone Marginal facies	700	1400	35,37-41
Penarth Group	20	20	34
Pant Mawr Sandstone	1	1	6,8,13,14, 18,26,27
Caswell Bay Mudstone	1	1	29
Undifferentiated Mercia Mudstone	800	20	34,36
Millstone Grit	0.1	n/a	37

The following observations were made during model calibration:

- Only one value of transmissivity per geology type was required to define the calibrated model.
- The Mercia Mudstone Marginal Facies typically exhibits higher transmissivity than the other formations (by an order of magnitude) and is within the expected range.
- The areas mapped as undifferentiated Mercia Mudstone is mapped as predominantly lower permeability mudstone[1], yet values similar to the marginal facies were required to achieve a good calibration:
    - Higher transmissivity values were necessary to obtain sufficient spring flows and maintain low groundwater heads at connection leading to New Mills Farm spring.
    - Transmissivity of other formations tended to dominate bulk transmissivity at other connections and results were less sensitive to the Mercia Mudstone value.
- Low transmissivity values for the Pant Mawr Sandstone were necessary to limit north-south connections around Grove and Pant Mawr and north of Cornelly quarry.
- An inferred low transmissivity connection between zones 36 and 37 due to the presence of Millstone Grit had only a minor effect on the overall calibration.

Superficial deposits

The final calibrated values of transmissivity for the superficial deposits at Merthyr Mawr and Kenfig are shown in Table 3.8. Note that the blown sand at Kenfig and Merthyr Mawr are modelled as unconfined; the hydraulic conductivity of the blown sand is constant, yet the transmissivity of the blown sand varies with the depth of the simulated groundwater level.

[1] Drilling of Boreholes O and R near New Mill farm springs showed that the geology in this area comprised marginal facies rather than the mudstone as mapped. This provides some justification for high transmissivities used in the model in this area.

Table 3.8 Calibrated transmissivity values for superficial deposits

Geology	Model transmissivity (m^2/day)		Zone
	Transient	Steady state	
Kenfig			
The blown sand	109-163	n/a	54-57
Sands and Gravels	50	90	46-52
Alluvium	0.5	n/a	53
Till+ Sands and Gravels [1]	0.05	n/a	49-52
Merthyr Mawr			
The blown sand	108-270	n/a	42-45

1 bulk transmissivity

The following observations were made during model calibration:

- The calibrated values for the hydraulic conductivity of the blown sand at Kenfig and Merthyr Mawr are 15 m/day and 20 m/day respectively. Jones (1993) carried out numerous falling head tests and estimated a mean hydraulic conductivity of around 9 m/day. Scoping calculations based on observed hydraulic gradients and estimated recharge suggest that the value could be up to 25 m/day (Appendix G of Appendix 7.1).
- The glaciofluvial sands and gravels at Kenfig represent a relatively permeable horizon, yet a limited connection to the sea via the till is required to support the observed groundwater levels.
- The lateral connection between the glaciofluvial deposits and the sea via the till represents a boundary connection and a bulk transmissivity. The equivalent transmissivity of the till would be approximately 0.0005-0.0009 m^2/day. Assuming a thickness of 8 m this is approximately an order of magnitude greater than the vertical till hydraulic conductivity (see Section 3.3.4).
- A relatively permeable lateral connection (via alluvium) is required from Kenfig Pool (Zone 53) to adjacent cells to achieve model calibration. Assuming a thickness of 5 m this gives a hydraulic conductivity of approximately 0.01 m/day, which is two orders of magnitude greater than the vertical hydraulic conductivity of the alluvium (see Section 3.3.4).

3.3.2 Depth dependent transmissivity

Flow into Cornelly quarry is principally via diffuse flow from fractures and fissures. Detailed work on the distribution of palaeokarst features (Appendix H of Appendix 7.1) indicates that most of the active fissures are present above 60 mbgl, with the frequency of clay filled features increasing significantly with depth. Very few fissures are observed below 100 mbgl toward the base of the quarry. Evidence also suggests that there are no significant palaeokarst features that may enhance groundwater flow from the current base of the quarry to at least -75 mAOD.

A review of the groundwater level hydrographs within the Carboniferous Limestone also suggests that a general model of enhanced permeability is applicable in a zone immediately above and below the position of the current water table. Groundwater levels fall rapidly after winter recharge, but generally most boreholes show a lower level to which groundwater levels fall. This lower level is typically controlled by the elevation of a zone of enhanced permeability.

These observations suggest up to three hydraulic conductivity horizons within the Carboniferous Limestone; with the highest values representative of an uppermost, reactivated palaeokarst zone, the middle zone representing partial reactivation and the lower zone representing an area of no reactivation.

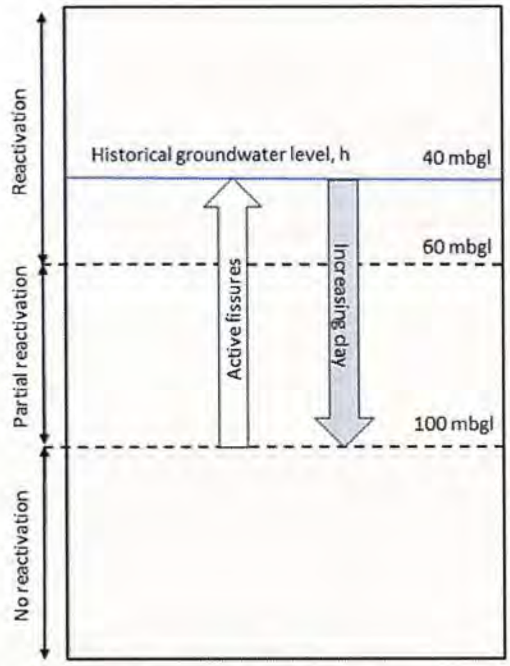


Illustration 3.5 .Palaeokarst features and VKD horizons at Cornelly quarry

Initial parameterisation of VKD was based on these three distinct hydraulic conductivity horizons in the Carboniferous Limestone. In summary, each layer elevation was defined as:

- top of layer 1, mean topographical elevation of each zone;
- top of layer 2, varies linearly with zone elevation;
- top of layer 3, top elevation of no reactivation, and;
- top of layer 4 (base of layer 3), the lower vertical limit of the model.

The top elevation of no reactivation was considered to be fixed at 0 mAOD based on the observations at Cornelly quarry. The lower bound to the model was set at -100 mAOD (at sufficient depth to consider future developments within the quarry). The base of the reactivated palaeokarst horizon (top of layer 2, $z_{j,L2}$) was considered to vary linearly with surface elevation according to:

$$z_{j,L2} = z_j . \frac{z_{max} - d_{max}}{z_{max}}$$

where z_j is the mean topographical elevation of each zone (m),

z_{max} is the maximum topographical elevation in the model area (m),

d_{max} is the depth to L2 at the maximum topographical elevation (m),

The figure below shows the resulting vertical extent of the horizons in each zone. The range of observed groundwater level variation is also shown and illustrates that the uppermost reactivated karst horizon is active at higher groundwater levels for this linear approximation.

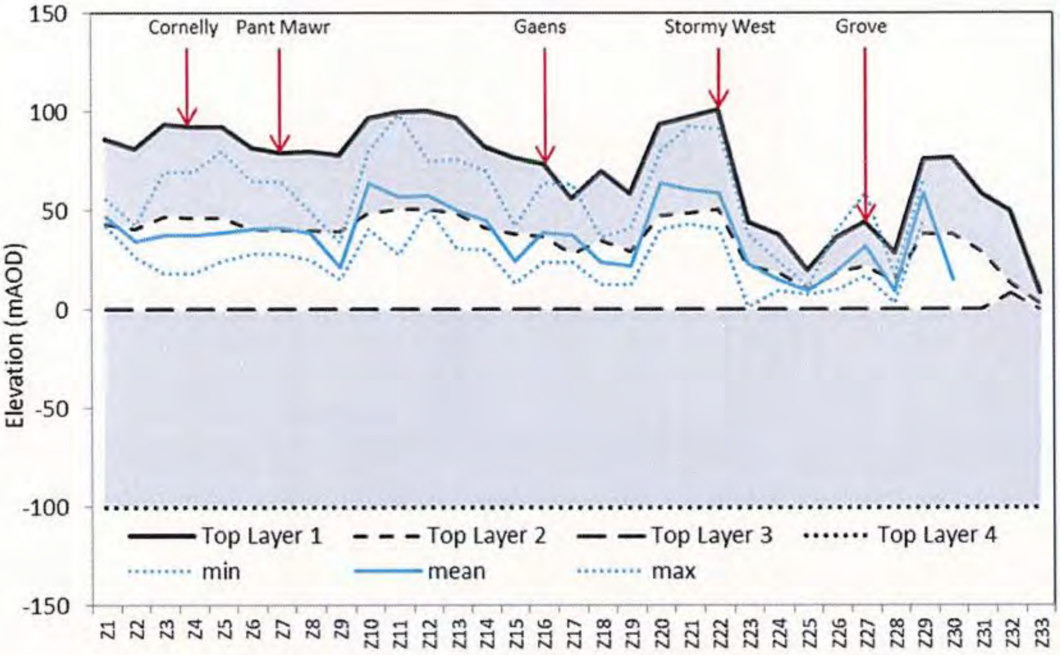


Illustration 3.6 VKD horizons by zone

In general, the initial parameterisation of layer elevations has remained unchanged during calibration. One exception is Zone 32 (associated with the outflow at Burrows well). The base of the zone of increased hydraulic conductivity at this location represents a physical discharge point from the aquifer.

A summary of the calibrated depth dependent hydraulic conductivity distribution at all Carboniferous Limestone zones is shown in Table 3.9. In order to limit issues of over parameterisation an attempt was made to restrict the number of distinct hydraulic conductivity values used. The vertical hydraulic conductivity profiles can be categorised in to broadly four categories (as shown on Table 3.9).

Table 3.9 Calibrated depth dependent hydraulic conductivity

		Layer Geometry (mAOD)				Hydraulic Conductivity (m/day)			
Id	ZONE	Top Layer 1	Top Layer 2	Top Layer 3	Top Layer 4	Layer 1	Layer 2	Layer 3	Category
Lagoon	Z1	86.1	43	0	-100	4.00	0.75	0.05	2
	Z2	81.3	41	0	-100	3.00	0.20	0.03	2
	Z3	93.6	47	0	-100	3.00	0.20	0.03	2
Cornelly Quarry	Z4	92.1	46	0	-100	4.00	0.75	0.05	2
	Z5	92.1	46	0	-100	0.01	0.01	0.01	1
	Z6	81.4	41	0	-100	3.00	0.20	0.03	2
Pant Mawr	Z7	79.0	40	0	-100	3.00	0.20	0.03	2
	Z8	80.1	40	0	-100	3.00	0.20	0.03	2
	Z9	77.8	39	0	-100	3.00	0.20	0.03	2
	Z10	96.8	49	0	-100	3.00	0.20	0.03	2
	Z11	100.1	51	0	-100	3.00	0.20	0.03	2
Stormy Down Quarry	Z12	100.5	51	0	-100	0.10	0.10	0.10	1
	Z13	96.7	49	0	-100	4.0	4.0	0.05	3
	Z14	82.1	41	0	-100	3.0	0.2	0.03	2
	Z15	76.5	39	0	-100	4.0	4.0	0.05	3
Gaens	Z16	73.9	37	0	-100	4.0	4.0	0.05	3
	Z17	55.9	28	0	-100	4.0	4.0	0.05	3
	Z18	70.0	35	0	-100	4.0	4.0	0.05	3
	Z19	58.3	29	0	-100	3.00	0.20	0.03	2
	Z20	93.8	47	0	-100	3.00	0.20	0.03	2
	Z21	97.1	49	0	-100	3.00	0.20	0.03	2
Stormy West Quarry	Z22	101.0	51	0	-100	3.00	0.20	0.03	2
	Z23	44.1	22	0	-100	5.0	5.0	0.05	3
EA South Cornelly	Z24	37.7	19	0	-100	4.0	4.0	0.05	3
	Z25	20.1	10	0	-100	4.0	4.0	0.05	3
	Z26	37.0	19	0	-100	5.0	5.0	0.05	3
Grove	Z27	44.0	22	0	-100	5.0	5.0	0.05	3
	Z28	28.8	15	0	-100	5.0	5.0	0.05	3
Itusca	Z29	76.0	38	0	-100	1.0	1.0	0.01	1
Plateau -	Z30	76.5	39	0	-100	4.0	4.0	0.01	3
Plateau -	Z31	58.3	29	0	-100	4.0	4.0	0.01	3
Plateau -	Z32	50.0	13	8.0	-100	50.0	4.0	0.01	4
Burrows Well	Z33	8.5	3	0	-100	10.0	1.0	0.01	4

3.3.3 Resultant transmissivity values

Transmissivity values between adjacent zones are calculated from the transmissivity of each geology type between adjacent cell nodal points from their harmonic mean (as detailed in Section 2.5). The transmissivity for each connection is shown on Figure 3.2. Minimum, maximum and mean transmissivity values are shown where transmissivity varies as function of the groundwater level over time.

This figure shows a large number of different transmissivities being applied between the zones both spatially and with time (derived from the smaller number of values of transmissivity within the zones).

3.3.4 Vertical hydraulic conductivity

Vertical component of flow have to be considered at Kenfig Dunes and Merthyr Mawr. Table 3.10 shows the calibrated vertical hydraulic conductivity values. The values are consistent with the range of values expected for lithologies of these types.

Table 3.10 Calibrated hydraulic conductivity values

Lithology	K_v (m/d)	Zones
Carboniferous Limestone	0.5	25,33
MMMF	1.0	37,38,39
Kenfig		
The Blown Sand	10	54-57
Sands and Gravels	0.1	46-52
Alluvium	1×10^{-4}	53
Lacustrine	5×10^{-5}	53,55-57
Till[1]	1×10^{-5}	47-52
Merthyr Mawr		
The blown sand	10	42-45
Till[1]	1×10^{-4}	42-45

1 vertical connection, not explicit model zone

In previous supplementary calculations (WynThomasGordonLewis, 2004) a water balance for the groundwater system at Kenfig pool estimated the vertical hydraulic conductivity of lacustrine deposits to be 10^{-4} m/day.

3.4 Storage

Storage parameters were assigned based on geology type (and other conceptual controls, such as confined and unconfined conditions) and further refined throughout the calibration process. The final calibrated storage values are shown on Figure 3.3 and summarised in Table 3.11 below. Calibrated values were typically well within expected ranges for these types of lithologies (see discussion below).

Table 3.11 Calibrated storage values

Zone	Storage	Zone	Storage	Zone	Storage	Zone	Storage
1	1.00×10^{-1}	16	1.23×10^{-2}	31	2.22×10^{-2}	46	2.00×10^{-1}
2	1.23×10^{-2}	17	1.23×10^{-2}	32	2.00×10^{-3}	47	2.00×10^{-1}
3	2.50×10^{-3}	18	1.23×10^{-2}	33	2.00×10^{-4}	48	5.00×10^{-4}
4	2.50×10^{-3}	19	1.23×10^{-2}	34	5.00×10^{-2}	49	5.00×10^{-4}
5	1.23×10^{-2}	20	2.50×10^{-3}	35	1.00×10^{-2}	50	5.00×10^{-4}
6	1.23×10^{-2}	21	1.23×10^{-2}	36	5.00×10^{-2}	51	5.00×10^{-4}
7	1.00×10^{-1}	22	1.23×10^{-2}	37	6.00×10^{-3}	52	5.00×10^{-4}
8	1.23×10^{-2}	23	2.50×10^{-3}	38	3.00×10^{-3}	53	1.00×10^{0}
9	1.23×10^{-2}	24	2.22×10^{-2}	39	5.00×10^{-2}	54	4.00×10^{-1}
10	2.50×10^{-3}	25	2.22×10^{-2}	40	2.00×10^{-2}	55	4.00×10^{-1}
11	2.50×10^{-3}	26	1.23×10^{-2}	41	5.00×10^{-2}	56	4.00×10^{-1}
12	1.00×10^{-1}	27	5.00×10^{-2}	42	3.00×10^{-1}	57	4.00×10^{-1}
13	1.23×10^{-2}	28	2.22×10^{-2}	43	3.00×10^{-1}	-	
14	1.23×10^{-2}	29	1.00×10^{-2}	44	2.50×10^{-1}	-	
15	1.23×10^{-2}	30	2.22×10^{-2}	45	2.50×10^{-1}	-	

Values of storage assigned to the unconfined Carboniferous Limestone varied between 2.0×10^{-3} 5.0×10^{-2}. Higher values of storage (0.1) were assigned to some Carboniferous Limestone zones (Zones 1, 7, 12) to account for additional storage in lagoons and pools. The lowest value of storage (2.0×10^{-4}) was assigned to the confined Carboniferous Limestone at Merthyr Mawr (Zone 33). Note that parameterisation of the confined Carboniferous Limestone at Merthyr Mawr causes some numerical issues, with lower values of storage causing model instability.

Storage values between 0.25 and 0.3 were used for the blown sand at Merthyr Mawr, whereas values of 0.4 were needed to represent the observed groundwater level fluctuations at Kenfig. The value at Kenfig represents the upper value of the expected range although it is not clear how much additional storage from the dune slacks may contribute to this figure.

3.5 Additional Storage

Three additional storage areas have been implemented in the calibrated model (summarised below in Table 3.12). Zone 1 represents the settlement lagoon associated with Cornelly quarry. Zone 42 and Zone 43 represent the pools and dune slacks to the south of the spring discharge at Burrows Well. Fractional areas (with respect to the zone area) and base elevations have been estimated from available survey data and groundwater levels. All bodies represent open water and a storage value of 1.0 is used.

Table 3.12 Additional storage areas

Zone	Elevation (mAOD)	Fractional area (-)	Storage (-)	Description
1	42	0.1	1.0	Lagoon
42	12	0.03	1.0	Upper Pool
43	8	0.07	1.0	Lower Pool

These additional storage areas were included where the existence of substantial surface water bodies are clearly apparent and may influence model results. Features such as dune slacks and other smaller surface water features are not explicitly represented in the model.

3.6 Boundary Conditions

3.6.1 Discharge

There are a number of licensed abstractions in the model area (Table 3.13). Discrete abstractions have been used to represent these pumping at their daily licensed values.

Table 3.13 Abstractions in the model area

Licence	X	Y	Description	Abs. (m^3/day)	Zone
21/58/51/0030	282240	180790	General Agriculture	14.6	23
21/58/33/0007	285640	178830	General Agriculture	22.7	29
21/58/51/0028	279850	183200	Commercial and Public Services	415.9	36
21/58/51/0010	279790	183480	Commercial and Public Services	1636.6	36
21/58/33/0004	282230	178120	General Agriculture	9.3	41
21/58/33/0006	282020	178550	General Agriculture	6.8	41

3.6.2 Springs

Spring boundary conditions are set at the observed spring elevations. The main springs that need to be simulated are those at New Mill Farm and Burrows Well, which are at elevations 7.9 mAOD and 13.0 mAOD respectively. Water discharging at Burrows Well is controlled via 'boundary re-direction' detailed in Section 3.6.4 below.

3.6.3 Drains

Kenfig Pool (Zone 53) has an average water level of around 10.3 mAOD which fluctuates by ±0.3 m in response to climatic conditions (Appendix K of Appendix 7.1). The pool is reported to be around 3.0 m deep and at high water levels overflows to the south west (Zone 55).

Kenfig pool is simulated as a distinct zone with a storage of 1.0 and an initial head of 10.4 mAOD. The base of the pool is effectively undefined, but a drain boundary condition is applied at 10.5 mAOD. Water overtopping this elevation is controlled via 'boundary re-direction' detailed in Section 3.6.4 below.

3.6.4 Boundary re-direction

Table 3.14 summarises the boundary re-direction implemented in the calibrated model.

Table 3.14 Boundary re-direction

Zone		Re-direction				Boundary
From	To	Area (m^2)	Fraction	Logic	Volume (m^3)	
32	42	163480	-	1	70654	Spring
32	43	371755	-	1	1000000	Spring
53	55	971716	1.0	0	0.0	Drain

Burrows Well

Redirection from Burrows Well (Zone 32) uses a logical process that best describes the conceptual understanding at this location. The logical process works in combination with the additional storage assigned to the upper pool (Zone 42) and lower pool (Zone 43) summarised in Table 3.12.

Within any given timestep the model accounts for the amount of storage in the upper pool and the quantity of spring flow available for re-direction. If the additional storage in Zone 42 exceeds 70654 m^3, any remaining spring flow is redirected to additional storage in Zone 43.

The maximum storage volume assigned to zone 32 is calculated from:

$$V_j = (S_{a,j} f_j A_j + S_j(1 - f_j)A_j).d_j$$

where V_j is additional storage volume (m^3),

$S_{a,j}$ and S_j are the additional and normal zone storage values respectively (-),

A_j is the zone area (m^2),

f_j is the fractional area of additional storage (-),

d_j is the additional storage depth (m),

The area of the upper pool (Zone42) is estimated to be 5262 m^2. Assuming the depth of the pool is approximately 1.4m this gives a total additional storage volume of water 70654 m^3. Pool volume in Zone 43 set to a sufficiently high value such to ensure all remaining spring flow can be re-directed and the water balance within the model is conserved.

Kenfig Pool

Redirection from Kenfig Pool (Zone 53) assumes that all water overtopping is discharged to Zone 55. .

3.7 Assessment of Calibration

In the following sections, the results of groundwater model are presented in terms of simulated groundwater heads, spring flows and water balances, and compared with observed data, where available.

3.7.1 Groundwater levels

A comparison between simulated and observed groundwater levels across the model area, are shown in Illustration 3.7-Illustration 3.11 (grouped spatially within model areas). These figures present the comparison of simulated groundwater heads at the nodal point of each cell and the corresponding observed data.

General acceptance criteria for a suitable representation of the simulations groundwater level timeseries are as follows:

1. A good representation of seasonal and long term trends should be achieved.
2. The ability of the model to replicate absolute observed groundwater levels is somewhat subjective (given that observation boreholes are not always located near to the cell node point), but groundwater levels simulated by the model are defined as good when within 5 m of the observed heads.

These criteria have been used to assess the simulation of groundwater level at the target locations listed in Table 3.1. 'Average' groundwater level residuals (observed-simulated) have been calculated for each target location. The time period used to calculate the 'average' groundwater level is defined by the availability of observation data at each location.

Table 3.15 Groundwater residuals

Zone	BH	mean error	absolute mean error	standard deviation	Zone	BH	mean error	absolute mean error	standard deviation
1	TQ3	6.9	7.8	4.2	29	I_TUSCA	-0.4	4.6	5.7
2	ESP2	0.5	2.7	3.7	30	T[1]	-	-	-
3	TM6	-6.1	8.7	10.8	33	MM1	0.5	1.2	1.4
4	TM6	-12.4	12.7	10.5	35	P	-6.2	6.1	2.5
5	TM4	-10.8	10.8	6.6	36	O-A	0.8	0.8	0.5
8	RW107	-1.6	4.3	5.5	38	A-A	-3.5	3.6	2.0
9	RWC105	0.4	3.7	4.4	40	B-A	0.2	1.5	2.1
10	G	-9.8	10.0	6.6	41	21	2.0	2.1	1.2
11	T95/01	-5.4	8.7	9.6	42	L	1.8	1.8	0.5
12	T95/04	1.1	6.4	7.5	43	D7	1.7	1.9	1.6
14	Q	-0.2	5.9	7.2	44	L	-5.1	5.1	0.4
15	E	2.1	4.6	5.2	45	D4	-0.4	0.5	0.4
18	RWC105	1.9	6.0	6.5	46	N-C	1.2	1.4	1.1
20	G	-2.9	5.9	6.9	47	A-B	-2.0	2.1	1.6
23	17B	-2.3	5.1	6.0	48	KP	-0.5	0.6	0.5
24	EASC	-1.4	2.6	3.3	50	K1A	-0.3	0.6	0.7
25	N-A	1.0	1.2	1.1	53	KP	0.2	0.3	0.2
26	RWC100	-0.3	2.9	3.6	55	K1B	-1.1	1.2	0.6
27	RWC100	4.3	5.2	4.2	56	CC5	-0.1	0.4	0.5
28	40	4.6	4.7	2.7					

1 observed data after end of simulation period

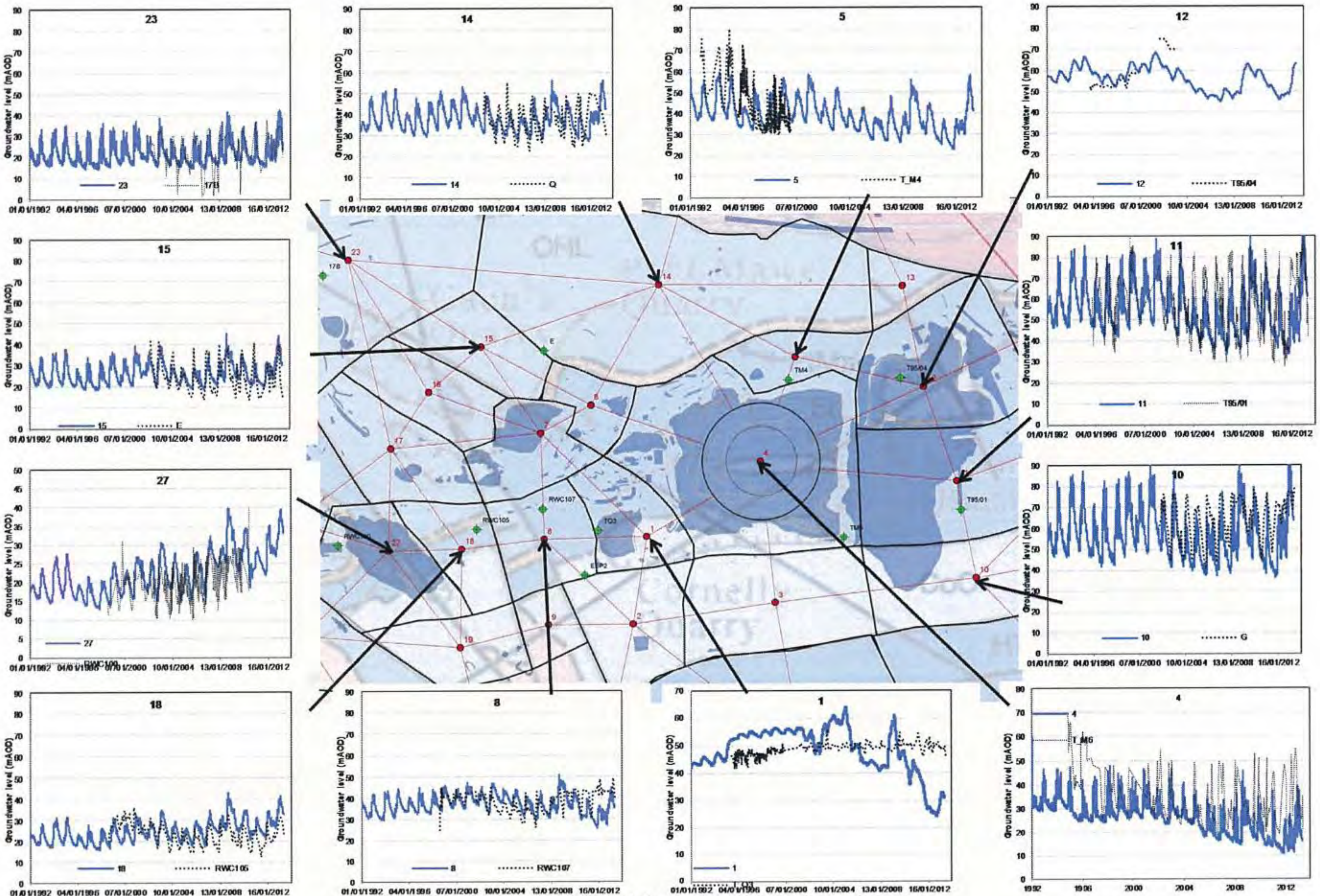


Illustration 3.7 Simulated and observed groundwater levels - Cornelly

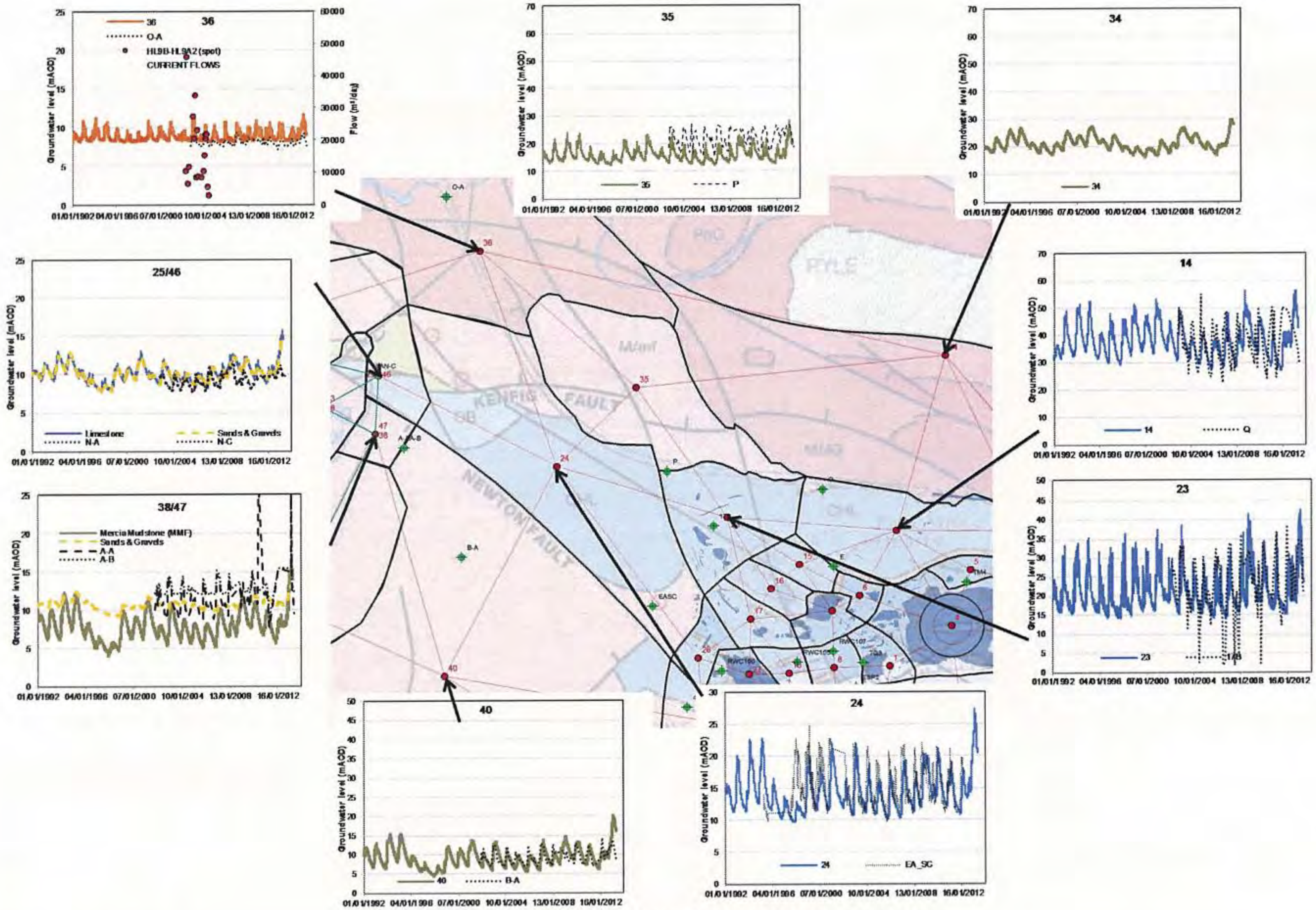


Illustration 3.8 Simulated and observed groundwater levels – N Cornelly

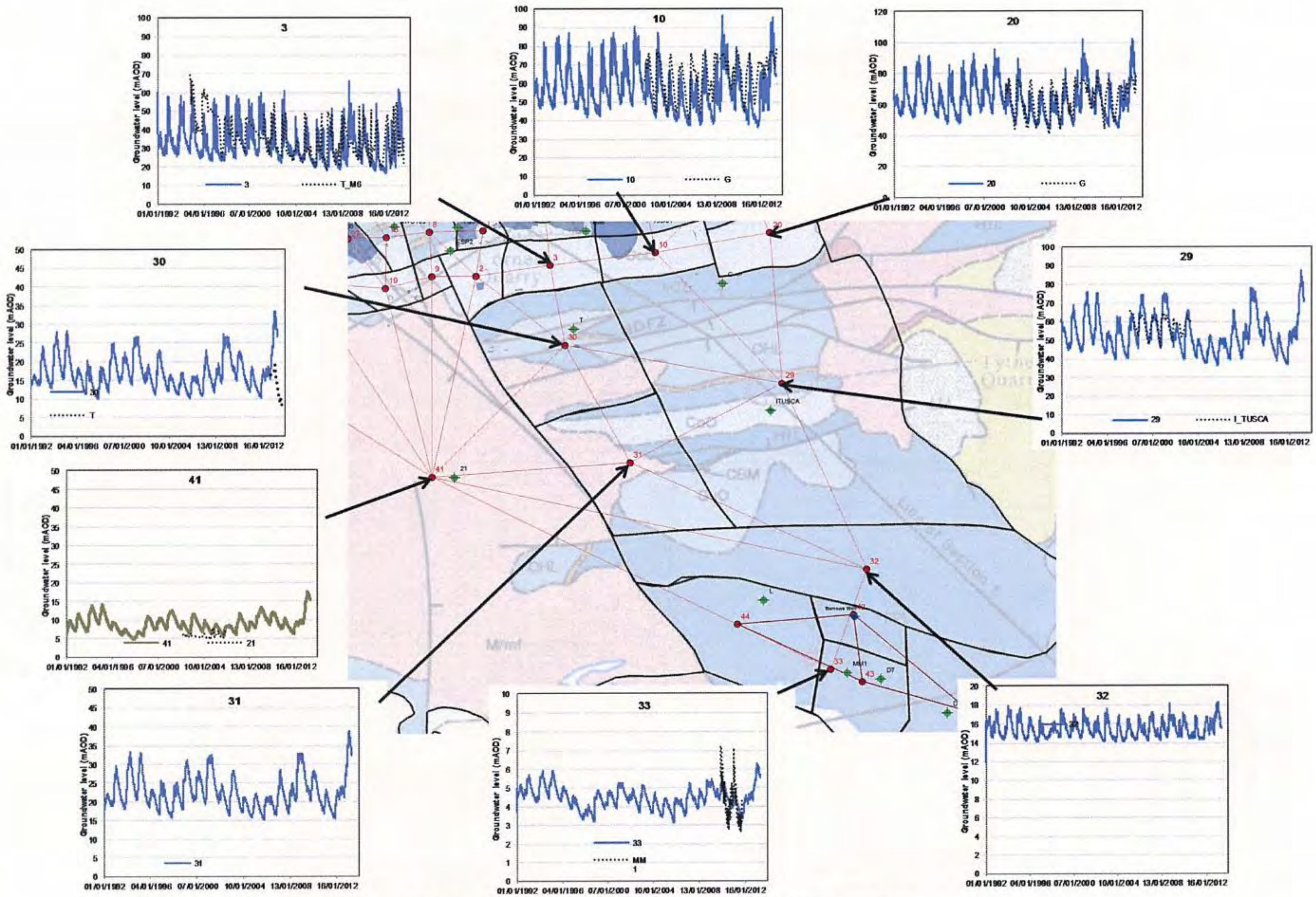


Illustration 3.9 Simulated and observed groundwater levels – Plateau

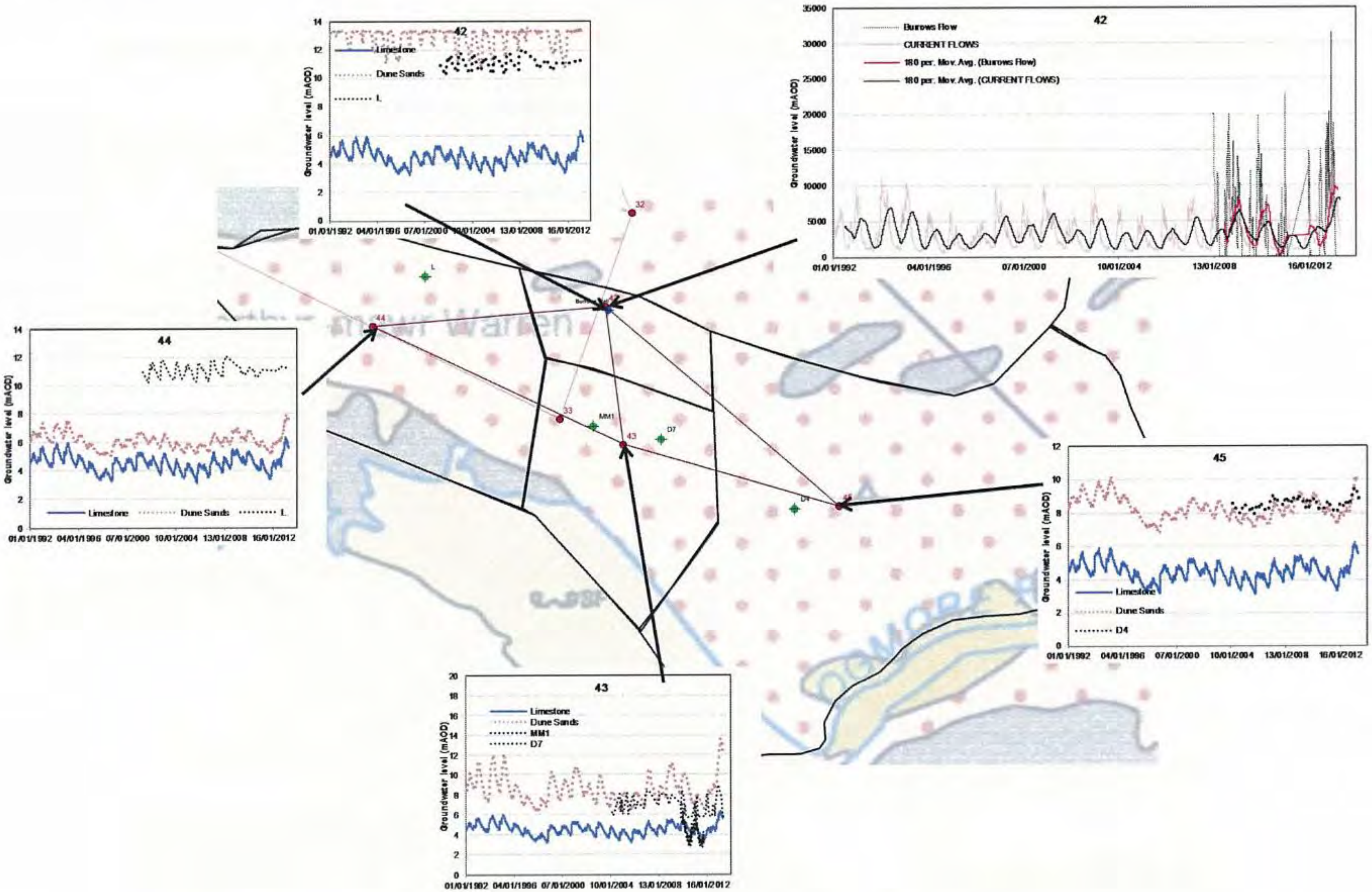


Illustration 3.10 Simulated and observed groundwater levels – Merthyr Mawr

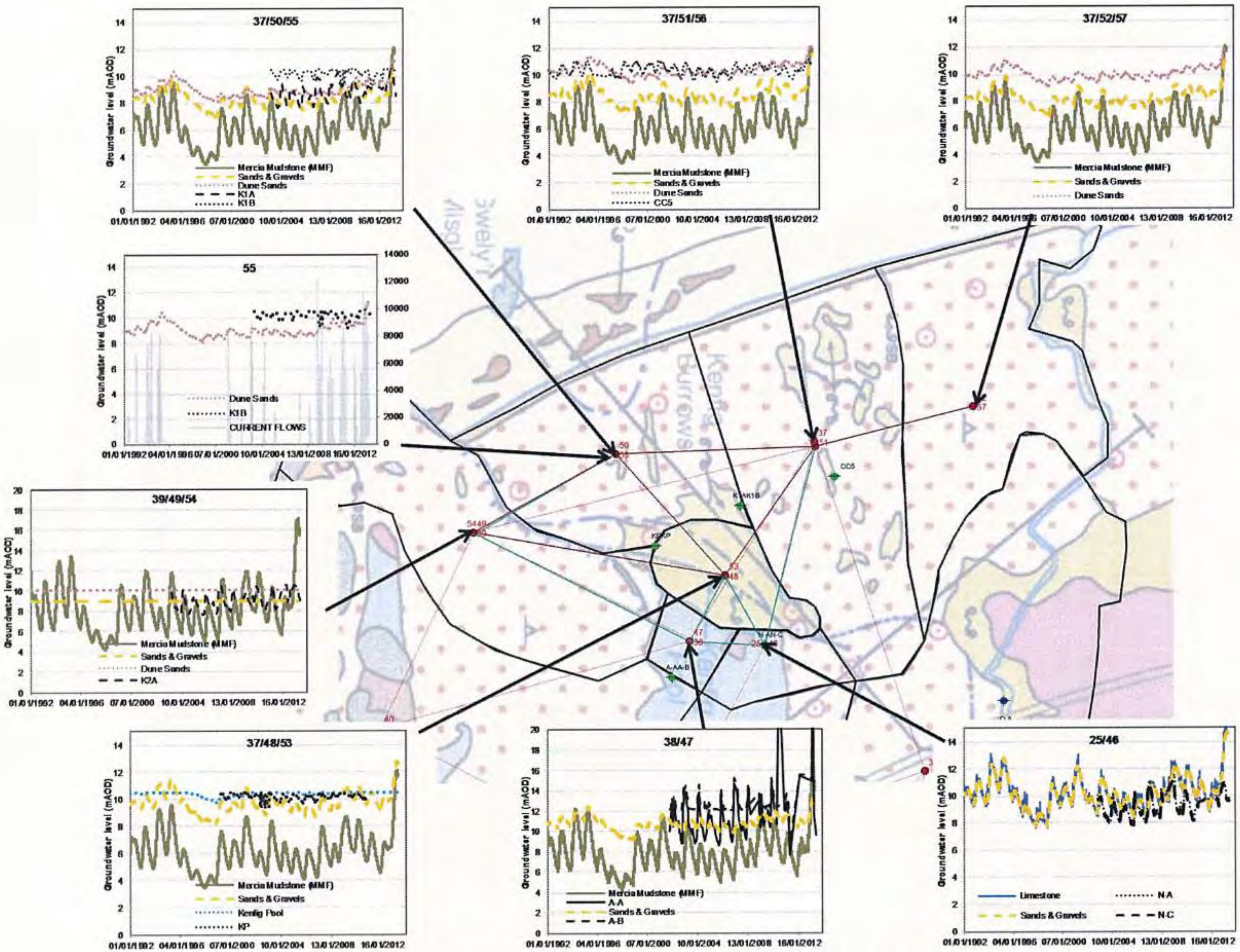


Illustration 3.11 Simulated and observed groundwater levels – Kenfig (North to right)

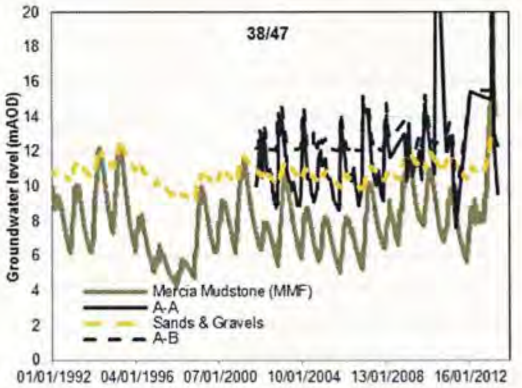
It can be seen that the model simulates the seasonal and long term groundwater level trends well. Average deviations between modelled and target heads in the superficial deposits is typically less than 2.0 m. The deviations in the simulated heads in the Carboniferous Limestone are typically 5.0 m or less. The average simulated groundwater levels are well within the total observed range and the calibration is considered acceptable. There are some obvious disparities, for example in Zone 1, where the observed groundwater level is that of the settlement lagoon, and is in all likelihood a perched groundwater level.

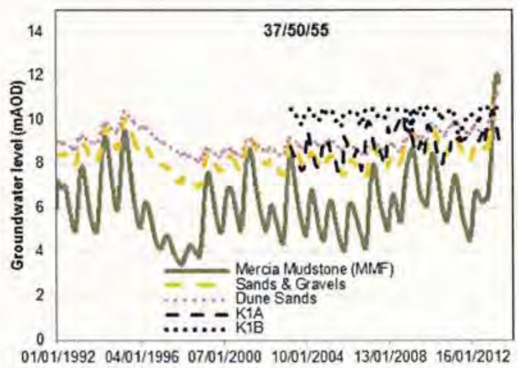
The greatest variations to the observed heads (>5.0 m) are in the vicinity of the Cornelly Quarry (Zones 3, 4, 5, 10, 11). At these locations the observation boreholes are typically at some distance from the modelled groundwater level. Given the relatively coarse zonal representation within the groundwater model and the large variation in the range in groundwater levels these absolute discrepancies are not unexpected and the observed trend is of greater significance in these locations.

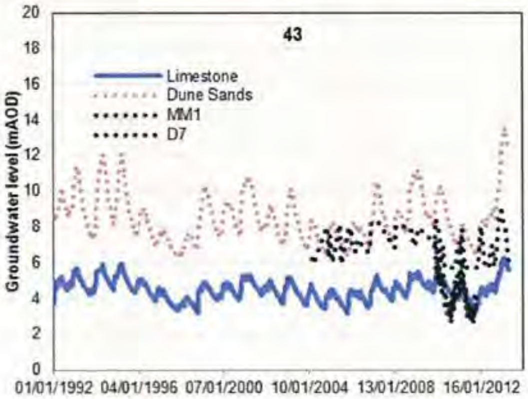
The ability of the model to simulate vertical gradients between the underlying geology and the dune systems at Kenfig and Merthyr Mawr can also be assessed. Table 3.16. compares the long term average simulated and observed groundwater gradients at multi-level monitoring locations (or those monitoring locations in the solid geology and superficial deposits located sufficiently close to allow an assessment).

Table 3.16 Vertical gradients

	Upper	Lower	i(obs)	i(mod)
Kenfig	A-B (GSG)	A-A (MMF)	0.16	0.28
Kenfig	K1B(DS)	K1A(GSG)	0.18	0.08
Merthyr Mawr	D7(DS)	MM1(CL)	0.40	0.60







The model simulates the long term groundwater level trends reasonably well, although the variation in the groundwater level in the underlying Carboniferous Limestone at Merthyr Mawr is underestimated due to model stability issues (Section 3.4). Discrepancies in the magnitudes of the vertical hydraulic gradient largely correspond with the distance between the observed and modelled groundwater levels, and their relative positions along each flow path.

3.7.2 Springs

Spring flows have been simulated by specifying an appropriate fixed head within the spring cell and deriving the flow from the model calculations. A comparison to available data at the gauging stations provides an indication of the ability of the model to reproduce observed flows.

New Mills Farm Springs

Modelled and observed flows at New Mill Farm Springs are shown on Illustration 3.12 and summarised in Table 3.17. Table 3.17 shows the long term average (LTA) observed and simulated flows over the period for which observations are available. The LTA at the New Mill Farm Springs are also shown demonstrating the variation under different recharge conditions.

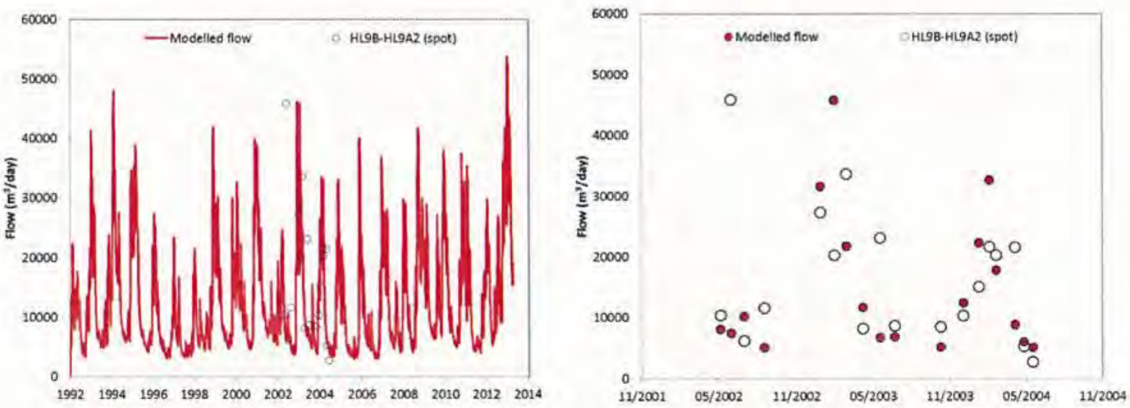


Illustration 3.12 New Mill Farm springs

Table 3.17 Observed and simulated flows at New Mill Farm Springs

Observed Flow (m^3/day)	Simulated Flow (m^3/day)	Difference[1] (%)	Comments
16735	14786	-11.7	Calibrated model
16735	17372	3.8	+15% recharge
16735	12379	-26.0	-15% recharge

1 relative to observed

Modelled flows are within 12% of the observed. Differences are relatively small given the overall uncertainty in the recharge rate (+/-15%) in addition to the relatively small number of spot gauging observations against which to compare model results. Simulated flow compares favourably with observed and together with simulated groundwater levels results are considered to provide an adequate representation of flows using current recharge estimates with the calibrated transmissivities of the various formations.

Burrows Well

Modelled and observed flows at Burrows Well are shown on

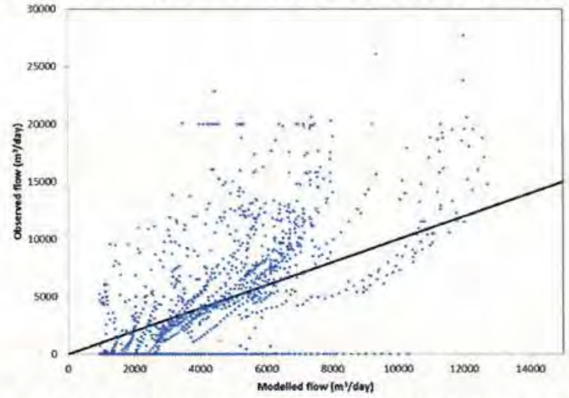


Illustration 3.13 as flow hydrographs and as a flow duration curve (flow hydrographs provide an indication of the accuracy of the model in simulating both magnitude and timing of flows; while flow duration curves assess the ability to reproduce flows under different flow conditions). Modelled versus observed flows are also shown on this figure.

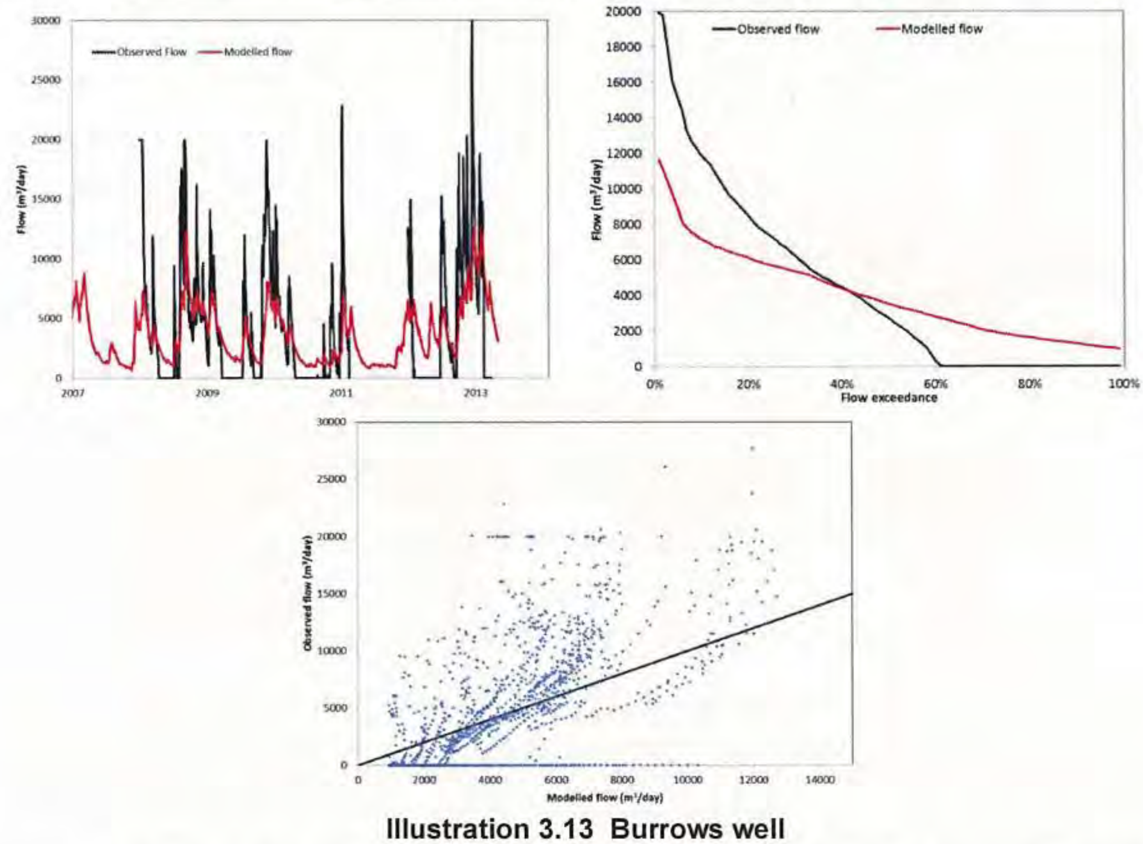


Illustration 3.13 Burrows well

Table 3.8 shows the average observed and simulated flows over the period for which observations are available. The LTA at the Burrows Well are also shown demonstrating the variation under different recharge conditions. Table 3.19 summarise key calibration statistics for average flows and Q95 flows respectively. •

Table 3.18 Observed and simulated LTA flows at Burrows Well

Observed Flow (m^3/day)	Simulated Flow (m^3/day)	Difference[1] (%)	Comments
4418	4047	-8.4	Calibrated model
4418	4685	6.0	+15% recharge
4418	3424	-22.5	-15% recharge

1 relative to observed

Table 3.19 Observed and simulated flows at Burrows Well

%	Observed (m^3/day)	Simulated	Difference
5	15,253	9,001	-41%
15	10,515	6,696	-35%
25	7,322	5,693	-22%
50	2,731	3,530	29%
75	0	1,831	-
85	0	1,444	-
95	0	1,122	-

LTA modelled flows are within 8.4% of the observed. These differences are not considered significant given the overall uncertainty in the recharge rate (+/-15%) and the subsequent variation in simulated flows. However, although the LTA flows are simulated reasonably well and the overall seasonal pattern of flows is also simulated effectively, the flow duration curve and modelled versus observed flows indicate that the model does not simulate the 'flashy' nature of Burrows Well. Simulated flows exceed observed at low flows, whereas flows are underestimated at peak flows.

Intermittent flow from the underlying Carboniferous Limestone and the discharges at Burrows Well involve the interaction between Zones 32-33 (Carboniferous Limestone), the Burrows well spring boundary, and re-direction to Zones 42-43 (Blown Sands). When groundwater levels in Zone 32 are sufficiently high, discharge occurs to Burrows Well by accessing the transmissivity above the spring elevation. Discharge to the Blown Sands from Burrows Well in turn interacts with the underlying Carboniferous Limestone in Zone 33. There is also a flow component between Zones 32 and 33 which accesses the transmissivity beneath the spring elevation, which influences groundwater levels at these locations. Difficulties in representing flows at Burrows Well largely derive from the complexity of the various transient interactions between zones at this location. Due to the low storage of the limestone, groundwater levels are significantly more variable than the sands aquifer which leads to model instability where the contrasts are large. The current parameterisation represents a compromise between a stable model and an acceptable groundwater level and flow calibration.

In general, the conclusion is that, whilst not ideal, the simulation of Burrows Well spring flow does match the transient patterns of observed spring flow reasonably well during flowing periods but does not manage to 'switch off' as rapidly as occurs in reality. Further analysis is carried out during the predictive modelling phase to determine if representing conditions closer to those observed would affect the conclusions in terms of simulated groundwater levels at Merthyr Mawr (see Section 4.6.3).

3.7.3 Pumping

Table 3.20 show results from annual monitoring data and the simulated flows over the same periods. As detailed in Section 3.1.3 calibration focussed on those periods which had complete records and where there was greater confidence in the quality of the observations.

Table 3.20 Observed and simulated flows at Cornelly quarry

	Observed Flow		Simulated Flow	
Period	Sump (m^3/day)	Offsite (m^3/day)	Sump (m^3/day)	Difference (%)
	Good data			
LTA (2001-2013)	3503[1]	-	3435	-1.9%
1 June 04 to 1 Oct 06	3382	1245	3295	2.6%
5 Aug 08 to 2 Jun 11	3735	2232	3761	-0.7%

	Poor data			
20 Jun 01 to 1 June 04	4873	1980	3559	27.0%
1 Oct 06 and 5 Aug 08	-	2281	3043	-
20 June 11 to 25 Mar 12	2969	2041	2458	17.2%

1 synthesised flow

The main inflows into Cornelly Quarry are direct recharge and groundwater inflow from the area within the cone of depression (including re-circulation from the settlement lagoon). Simulated inflows to Cornelly sump and the recirculation from the settlement lagoon are shown on Illustration 3.14.

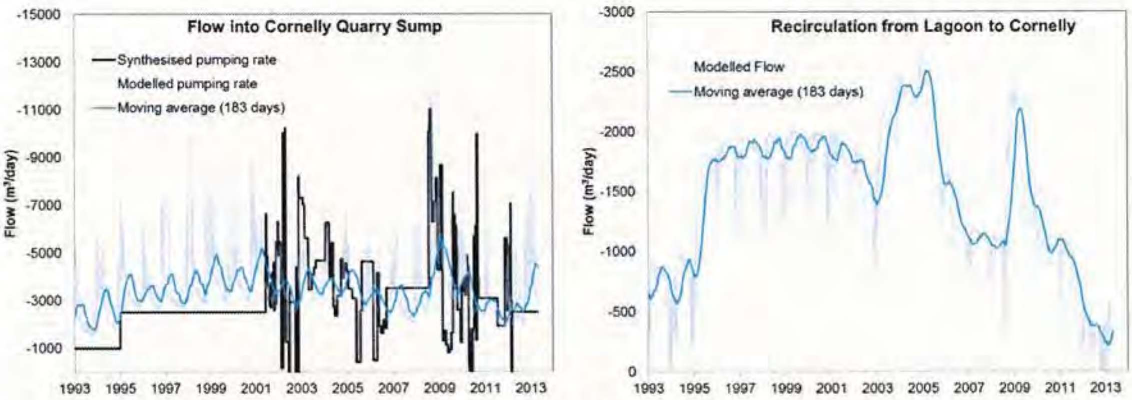


Illustration 3.14 Simulated flows at Cornelly sump

The LTA and selected data show a good agreement with the observed data and provide confidence in the model calibration. Earlier data (pre 2004) include periods of intermittent pumping when the quarry was allowed to flood. No water level measurements over this period (and less certainty in historical development depths) mean less confidence is attributed to simulated flows over this period. Records are missing between 1 Oct 2006 and 5 Aug 2008. The quality of the data post June 2011 is questionable.

Over the model calibration period re-circulation from the lagoon is typically between 1000 and 2000 m^3/day. This is broadly consistent with the difference between the sump flow and the flows pumped offsite.

3.7.4 Water balance

Model water balance

Illustration 3.15 presents the time-series water balance for each hydrogeological year (April to March) for the calibrated model. Table 3.21 summarises the model water balance over the duration of the simulation period. Average flows between zones are shown on Figure 3.4.

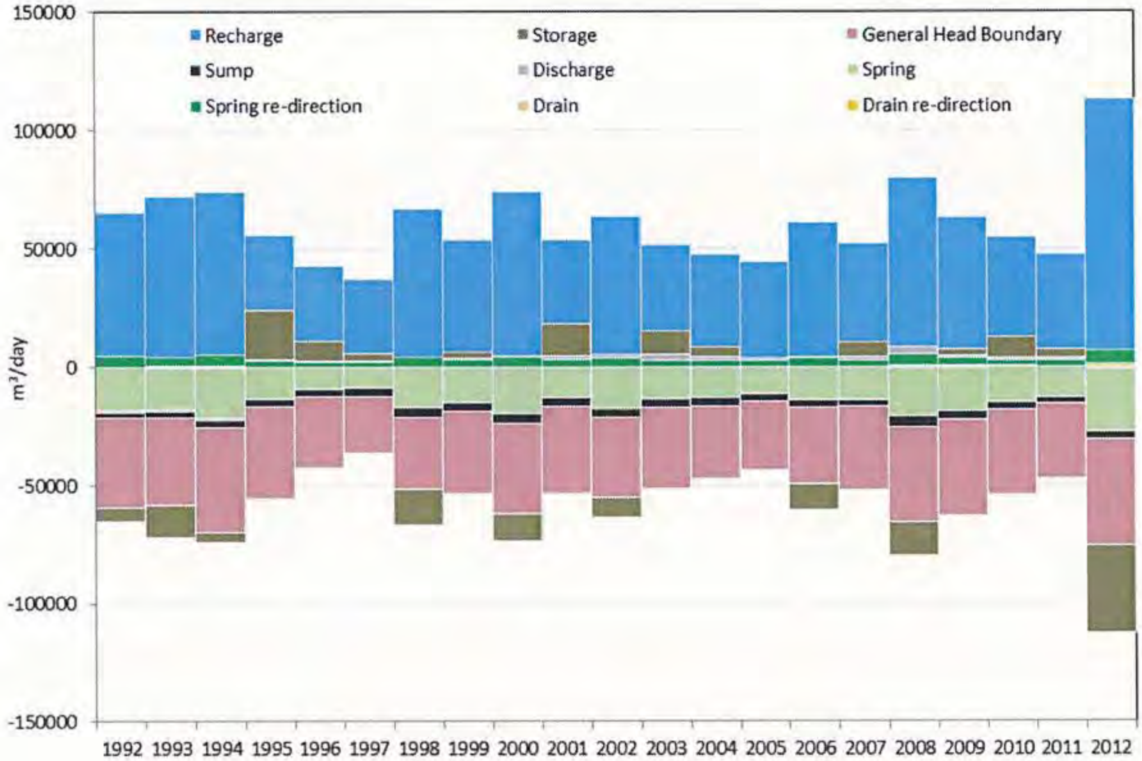


Illustration 3.15 Calibrated model water balance

Table 3.21 Model water balance over simulation period (m^3/day)

Recharge	Storage	GHB	Sump	Discharge	Spring	Drain
52,133	1,709	-35,334	-3,392	810	-15,753 (3,245)	-183 (183)

Numbers in parentheses show re-direction rates

The dominant inflow is recharge, averaging 52,000 m^3/day. A nominal inflow comprises discrete 'discharges'; the difference between consumptive abstractions and redistribution of inflow to Cornelly Quarry during historical pumping. The principal outflow is discharge to the sea via general head boundaries, which average 35,000 m^3/day, or 69% of all outflows. Spring flow (16,000 m^3/day or 31%) accounts for the remaining discharge (which comprises the discharge at New Mills Farms spring, as the flow from Burrows Well is subsequently recharged into the blown sand at Merthyr Mawr).

Kenfig water balance

Illustration 3.16 presents the time-series water balance for the Kenfig the blown sand (this excludes Kenfig Pool, other than via lateral flows and overtopping from the pool which form boundary flows to the blown sand). Table 3.22 summarises the water balance over the duration of the model period.

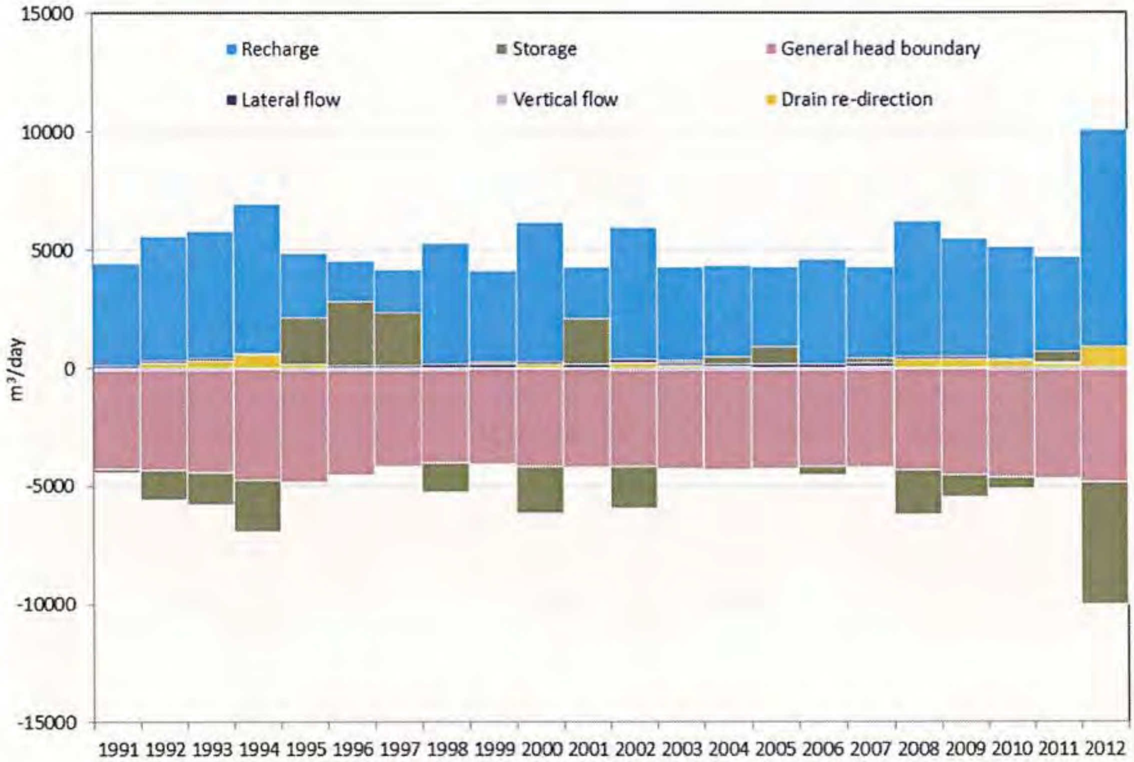


Illustration 3.16 Kenfig dune water balance

Table 3.22 Kenfig water balance over simulation period (m^3/day)

Recharge	Storage	GHB	Lateral	Vertical	Drain Re-direction
4,478	374	-4,298	104	-91	181

The dominant inflow to Kenfig blown sand system is recharge, which averages 4,500 m^3/day and amounts to approximately 94% of all inflows over the model duration (this is consistent with previous estimates (ESI,, 2004). There is a small component of lateral flow from Kenfig Pool (100 m^3/day or 2.2%). Overtopping from Kenfig pool into the blown sand also contributes a small component of inflow (180 m^3/day or 3.8%). Groundwater flow through the blown sand and discharge to the sea is the main component of outflow, with a small component of downward leakage into the underlying sands and gravels (90 m^3/day or 2.0%).

Merthyr Mawr water balance

Illustration 3.17 presents the time-series water balance for the blown sand at Merthyr Mawr. Table 3.23 summarises the water balance over the duration of the model period.

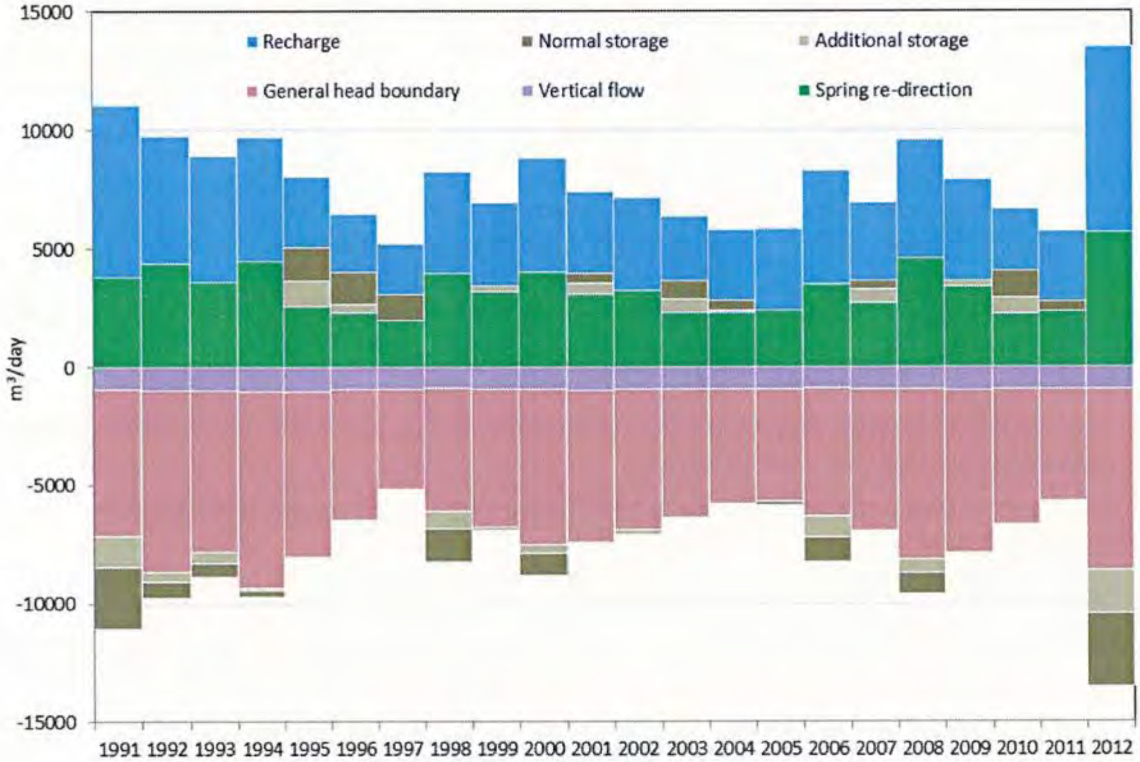


Illustration 3.17 Merthyr Mawr dune water balance

Table 3.23 Merthyr Mawr water balance over simulation period (m^3/day)

Recharge	Spring re-direction	Normal storage	Additional storage	GHB	Vertical
4,010	3,252	-120	-81	-6,101	-960

Spring flows at Burrows Well account for 3,300 m^3/day (45 %) of the total inflow to the dune system, with direct recharge contributing the remainder (4,000 m^3/day or 55 %). The principal outflow from the blown sand is discharge to the sea (6,100 m^3/day or 86%) with a significant proportion also lost via downward leakage to the underlying Carboniferous Limestone (960 m^3/day or 14%).

3.8 Model Validation

The model was validated by checking to see what effect it predicts if there was no quarry dewatering. Although there are no reliable groundwater level data for the period prior to the start of dewatering at Cornelly Quarry, anecdotally this is thought to be around 60 mAOD. The validation test shows that groundwater levels around Cornelly quarry rise from an average of 25.7 mAOD to around 52.6 mAOD over the simulated period (range 42.1-81.0 mAOD). This provides some additional confidence in the ability of the model to predict heads correctly over a wide range of conditions.

3.9 Sensitivity Analysis

A formal sensitivity analysis was carried out to investigate the level of uncertainty associated with several aspects of the model calibration. Previous phases of investigation have succeeded in clarifying many aspects of the conceptual understanding of the system, but several aspects related to the connections between the dune sand aquifers and underlying geology at Kenfig, and the conceptual representation of the dune system at Merthyr Mawr are unclear. In summary, these uncertainties include:

- The extent, thickness and hydraulic conductivity of the estuarine clay underlying the blown sand system and pool at Kenfig.
- The extent, thickness and hydraulic conductivity of the till underlying the glaciofluvial deposits at Kenfig.
- The connectivity of the glaciofluvial deposits at Kenfig to the coast.
- Lateral connection between glaciofluvial deposits and Kenfig pool (ephemeral seeps).
- Lateral connection between Kenfig pool and the blown sand.
- The thickness and hydraulic conductivity of the till underlying the blown sand system at Merthyr Mawr.
- The connectivity of the blown sand at Merthyr Mawr to the coast.
- The role of pool storage at Merthyr Mawr.

A more detailed list of the sensitivity runs is shown in Table 3.25. The sensitivity runs were designed in consultation with technical staff including detailed discussions with NRW in 2013.

3.9.1 Sensitivity results

Discussion with Natural Resources Wales had highlighted the need for sensitivity analysis in order to ensure that the model parameterisation could be justified. Where this revealed some element of model equivalence, this was then taken forward to the sensitivity analysis of predictive scenarios. Table 3.24 summarises the parameters that have been carried through to a sensitivity analysis on the predictive runs.

For each sensitivity run a comparison is made between the simulated changes in conditions and the calibrated model. A summary of the model sensitivity results due to the modifications to the conceptual model is outlined in Table 3.25.

A more detailed description of the sensitivity results are shown in Table 3.26-Table 3.31. The graphs in these tables show the difference in the simulated groundwater levels between the calibrated model and the results due to each particular variation in model parameterisation. Selected results are shown for Zone 51 (Glaciofluvial deposits) and Zone 56 (Blown Sand) at Kenfig. At Merthyr Mawr model results are shown for Zone 33 (Carboniferous Limestone) and Zone 45 (Blown Sand).

Table 3.24 Sensitivity runs in the predictive phase

Zones	Prediction	Sensitivity	Parameter		Unit	Calibrated	Sensitivity
42	SENS1	17.2	V	Pool storage	m^3	5262	10524
42	SENS2	17	V	Pool storage	m^3	5262	2631
48-53	SENS3	4.1	K	Estuarine Clay	m/d	1.33×10^{-5}	2.00×10^{-5}
46-53	SENS4	12.2	T	Alluvium	m^2/d	9.54	6.93
47-53	SENS5	11.2	T	Alluvium	m^2/d	1.20×10^{1}	8.87
53,55-57	SENS6	13.1	T	Alluvium	m^2/d	3.55×10^{1}	2.69×10^{1}
47-38	SENS7	9.1	K	Till	m/d	1.62×10^{-4}	2.25×10^{-4}
all	SENS8	n/a	R+T			-	+ 15%
all	SENS9	n/a	R+T			-	-15%

V pool storage; K bulk vertical hydraulic conductivity; T bulk transmissivity; R recharge

Table 3.25 Summary of model sensitivity runs

Run	Area	Zone	Parameter	Unit	Calibrated	Parameter range	Comment
1	Kenfig	46-53	Till	m/d	1.0×10^{-5}	K_v inc. $1.6\times10^{-4} - 6.0\times10^{-4}$	An increase in bulk vertical hydraulic conductivity of the till improves the connection between the GFD and underlying solid geology, allowing groundwater to drain downwards. Groundwater levels decrease in all zones with the exception of the underlying solid geology. The blown sand experience a drop of up to 10cm over the modelled parameter range.
2	Kenfig	50-52	Till coastal	m^2/d	5.0×10^{-2}	T inc./dec. $7.0\times10^{-3} - 1.0\times10^{-2}$	Model calibration is extremely sensitive to the lateral connection which controls the discharge between the GFD and the coast. In the calibrated model till is assumed to limit this connection at the seaward boundary. Increasing the bulk transmissivity allows more water to leave the model from the GFD. Groundwater levels are significantly reduced in the GFD, which in turn increase the downward leakage from the overlying the blown sand. Conversely, a reduction in till transmissivity produces a groundwater level increase in the effected zones. A low transmissivity connection is required to maintain adequate model calibration.
3	Kenfig	46-53	Till	m/d	1.0×10^{-5}	K_v dec. $1.3\times10^{-4} - 1.6\times10^{-4}$	A decrease in the bulk hydraulic conductivity of the till causes increased groundwater levels in all cells above the till and a reduction in groundwater levels in the underlying solid geology. An increase of 10cm is simulated within the blown sand for the maximum decrease in vertical connectivity.
4	Kenfig	46-53	Estuarine Clay	m/d	5.0×10^{-5}	K inc. $4.0\times10^{-5} - 1.3\times10^{-4}$	The low K lacustrine layer beneath the blown sand is necessary to keep the dune sand aquifer perched. Increasing the bulk vertical hydraulic conductivity causes water to drain from the perched aquifer and increase groundwater levels in all underlying layers.
5	Kenfig	46-53	Estuarine Clay	m/d	5.0×10^{-5}	K dec. $2.0\times10^{-5} - 3.0\times10^{-5}$	The low K lacustrine layer beneath the blown sand is necessary to keep the dune sand aquifer perched. Decreasing the bulk vertical hydraulic conductivity reduces groundwater levels in underlying zones, as groundwater is retained within the blown sand and downward leakage is reduced.
6	Kenfig	57	Estuarine Clay	m/d	5.0×10^{-5}	K inc. $3.0\times10^{-5} - 1.3\times10^{-4}$	Increasing the connectivity between the northern dunes and the GFD causes effects as described in Run 4, but more localised. Groundwater levels in the blown sand drop by several cm for the maximum increase in parameter values.
7	Kenfig Pool	53	Estuarine Clay	m/d	5.0×10^{-5}	K inc. $1.3\times10^{-5} - 1.3\times10^{-4}$	Increasing bulk hydraulic conductivity beneath the pool causes a decrease in pool and dune sand groundwater levels. A subsequent increase in groundwater levels in the underlying GFD and solid geology is simulated due to increased downward leakage, although changes are typically less than 4cm.
8	Kenfig Pool	53	Estuarine Clay	m/d	5.0×10^{-5}	K dec. $1.3\times10^{-5} - 1.2\times10^{-5}$	Decreasing bulk hydraulic conductivity beneath the pool causes an increase in pool land the blown sand groundwater levels. A subsequent decrease in groundwater levels in underlying GFD and solid geology is simulated due to decreased downward leakage, although changes are typically less than 4cm.
9	Kenfig	38	Till	m^2/d	2.0×10^{-5}	K inc./dec. $1.3\times10^{-4} - 6.0\times10^{-4}$	Increasing bulk hydraulic conductivity of the till causes groundwater levels in the GFD to decrease as more groundwater drains into the underlying MMMF, where groundwater levels subsequently increase. The opposite effects are simulated for a bulk with decreased till vertical hydraulic conductivity. All simulated changes in groundwater levels are less than 10 cm.
10	Kenfig	25	Till	m/d	1.2×10^{-1}	K dec. $1.6\times10^{-5} - 1.2\times10^{-1}$	Decreasing the vertical connection between the GFD and CL causes increase groundwater levels within the blown sand and the GFDs. Changes in groundwater levels are typically large (up to 1.5m) in all zones.
11	Kenfig	47	Alluvium	m^2/d	5.0×10^{-1}	T inc./dec. 8.9×10^{0} - 2.7×10^{1}	Increasing the transmissivity (lateral seeps) between the GFDs (Zone 47) and Kenfig pool (Zone 53) produces model instability at high parameter values (>27m^2/day). Long term trends show a decrease in groundwater levels in the GFDs. A decrease in transmissivity produces the opposite effect in all cells. All changes are relatively small (<15cm). Kenfig pool shows little change (+/- 1cm).
12	Kenfig	46	Alluvium	m^2/d	5.0×10^{-1}	T inc./dec. $6.9\times10^{0} - 2.4\times10^{1}$	Increasing the transmissivity (lateral seeps) between the GFDs (Zone 46) and Kenfig pool (Zone 53) produces model instability at high parameter values (>24m^2/day). Long term trends show a decrease in groundwater levels in the GFDs and the blown sand (<5cm). A decrease in transmissivity produces the opposite effect in all cells. All changes are relatively small (<15cm). Kenfig pool shows little change (+/- 1cm).
13	Kenfig	55-56	Alluvium	m^2/d	5.0×10^{-1}	T inc. $3.6\times10^{1} - 2.7\times10^{1}$	Increasing the transmissivity from Kenfig Pool to the blown sand produce peaks/troughs during 1998/1999 at Kenfig Pool, GFDs and underlying solid geology. The blown sand show a modest decrease in groundwater levels. Zone 55 (which receives overtopping water from Kenfig Pool) shows a decrease in groundwater levels. Changes are typically small (<5cm) in all zones.
14	Kenfig	55-56	Alluvium	m^2/d	5.0×10^{-1}	T dec. $3.2\times10^{1} - 4.1\times10^{1}$	Decreasing the transmissivity from Kenfig Pool to the blown sand produces peaks/troughs during 1998/1999 at Kenfig Pool, GFDs and underlying solid geology. The blown sand show a modest increase in groundwater levels. Zone 55 which receives overtopping water from Kenfig Pool shows an increase in groundwater levels. Changes are typically small (<5cm) in all zones.
15	Kenfig	55-57	Initial heads	m	-	Initial head inc./dec. ±1	An increase and decrease in initial heads in the blown sand caused up to a 10cm change in groundwater levels in the GFD. Groundwater levels returned to their previous values over the simulation period.
16	Merthyr Mawr	42-45	Till	m/d	7.0×10^{-4}	K inc./dec. $4.0\times10^{-4} - 1.3\times10^{-3}$	Groundwater levels in the blown sand are very sensitive to the bulk hydraulic conductivity of the till. A ±0.5m change in thickness (an increase or decrease in bulk conductivity) produces a decrease/increase of up to 1.0m in dune sand groundwater levels. The model failed when the thickness of the till was reduced to less than 0.4m (bulk hydraulic conductivity >1.3×10^{-3})
17	Merthyr Mawr	42/43	Pool storage	m^3	5262 1000000	Volume inc./dec. 2631 – 5262 13879 - 41637	Increasing and decreasing the pool storage at Merthyr Mawr by 50% changed groundwater levels by up to 4.5m. Mass balance errors occurred where less storage was available than spring discharge requiring an arbitrarily large value to be assigned to the lower pool. Variation of the top pool parameters alone was less sensitive to change.
18	Merthyr Mawr	43-45	Sand	m/d	20	T inc./dec. 17 – 23	The model is very sensitive to the depth dependent transmissivity of the lateral connection between the blown sand and the coast. Increasing the hydraulic conductivity (transmissivity) allows more water to leave the model, decreasing groundwater levels in all zones (and vice versa). A 15% change in the hydraulic conductivity produces change up to 0.5m in the sands and underlying limestone.

GFD: glaciofluvial deposits; MMMF Mercia mudstone marginal facies; CL Carboniferous limestone

Table 3.26 Sensitivity analyses results (Runs 1-3)

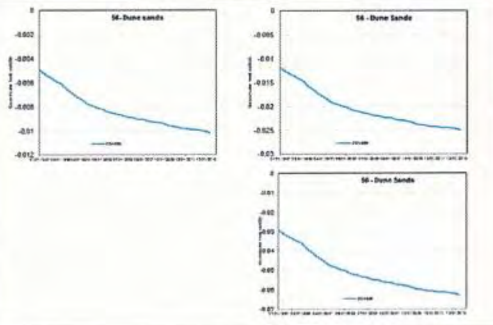
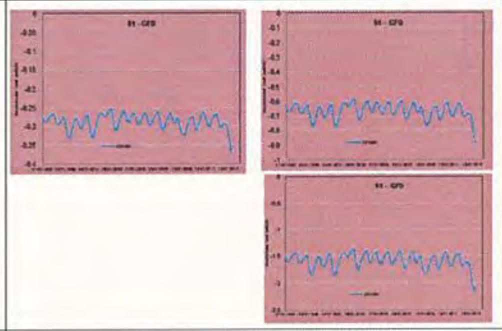
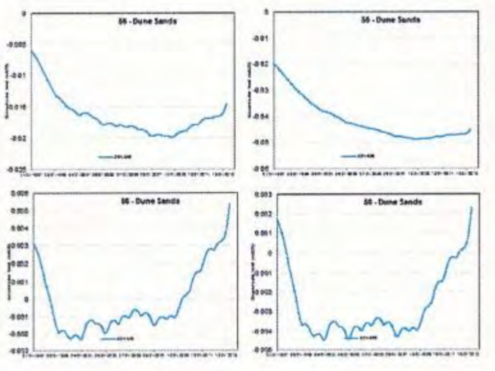
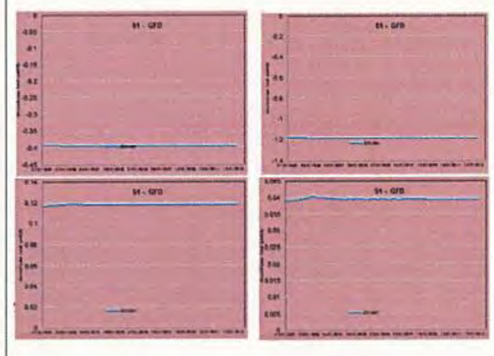
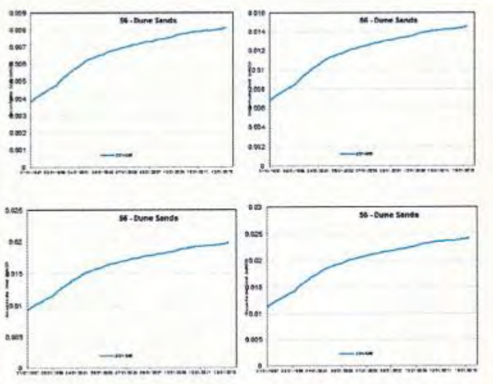
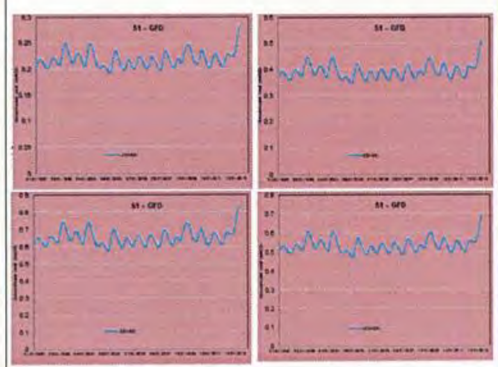
Number	Hydraulic Conductivity (m/d)	Layer Thickness (m)	Transmissivity (m2/d)	Second area Transmissivity (m2/d)	Dune Sands (Graphs in numerical order clockwise from top left)	Glaciofluvial Deposits/Limestone (Graphs in numerical order clockwise from top left)
Calibration	0.0001	8	1.62E-04			
1	0.0001	6	1.83E-04	-		
1.1	0.0001	4	2.25E-04	-		
1.2	0.0001	1	5.98E-04	-		
Calibration	-	8	0.01 (lateral)	0.00016 (vertical)		
2		8	2.00E-02	1.60E-04		
2.1		8	4.00E-02	1.60E-04		
2.2		8	9.00E-03	1.60E-04		
2.3		8	7.00E-03	1.60E-04		
Calibration	0.0001	8	1.62E-04			
3	0.0001	10	1.50E-04	-		
3.1	0.0001	12	1.42E-04	-		
3.2	0.0001	14	1.36E-04	-		
3.3	0.0001	16	1.31E-04	-		

Table 3.27 Sensitivity analyses results (Runs 4-6)

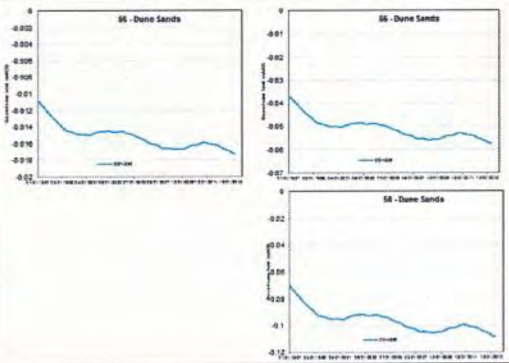
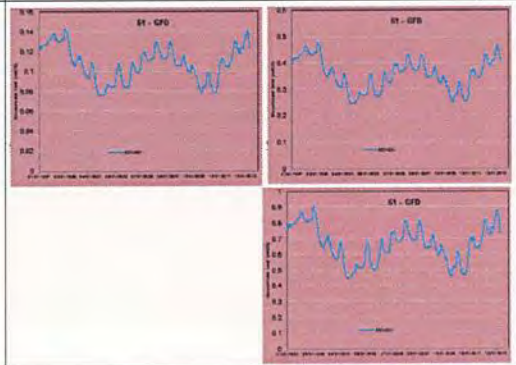
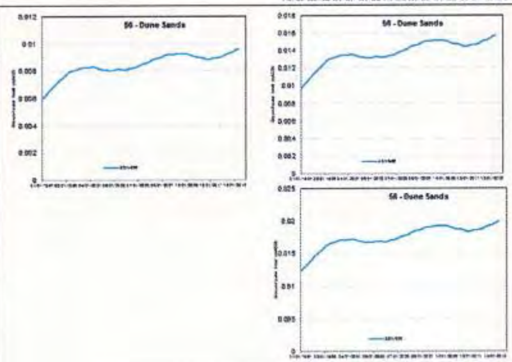
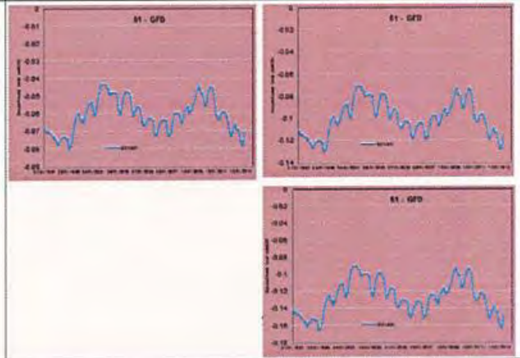
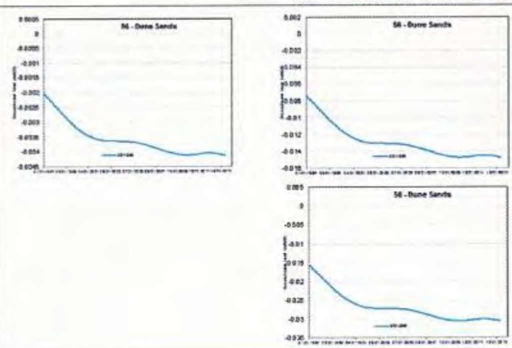
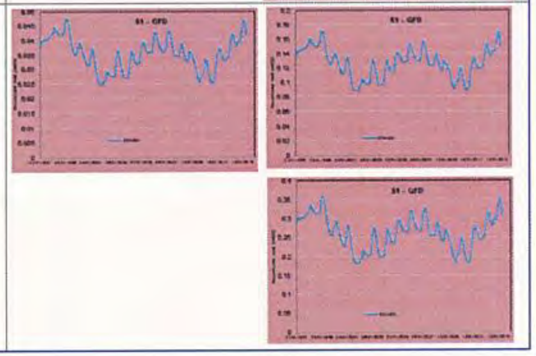
Number	Hydraulic Conductivity (m/d)	Layer Thickness (m)	Transmissivity (m2/d)	Second area Transmissivity (m2/d)	Dune Sands (Graphs in numerical order clockwise from top left)	Glaciofluvial Deposits/Limestone (Graphs in numerical order clockwise from top left)
Calibration	0.00001	3	Under Pool T	Under Sands T		
			1.33E-05	3.00E-05		
4	0.00001	2	1.50E-05	4.00E-05		
4.1	0.00001	1	2.00E-05	7.00E-05		
4.2	0.00001	0.5	3.00E-05	1.30E-04		
Calibration	0.00001	3	Under Pool T	Under Sands T		
			1.33E-05	3.00E-05		
5	0.00001	4	1.25E-05	2.50E-05		
5.1	0.00001	5	1.20E-05	2.20E-05		
5.2	0.00001	6	1.17E-05	2.00E-05		
Calibration	0.00001	3	3.00E-05			
6	0.00001	2	4.00E-05	-		
6.1	0.00001	1	7.00E-05	-		
6.2	0.00001	0.5	1.30E-04	-		

Table 3.28 Sensitivity analyses results (Runs 7-9)

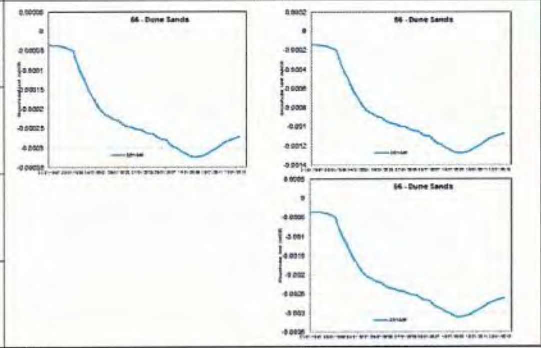
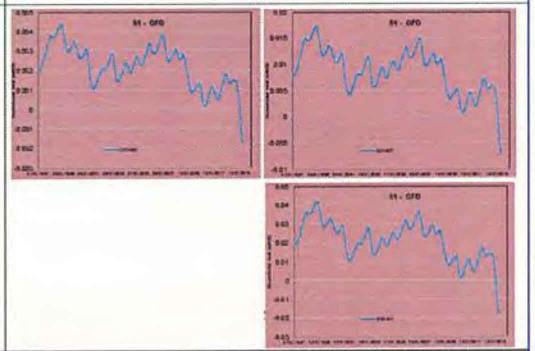
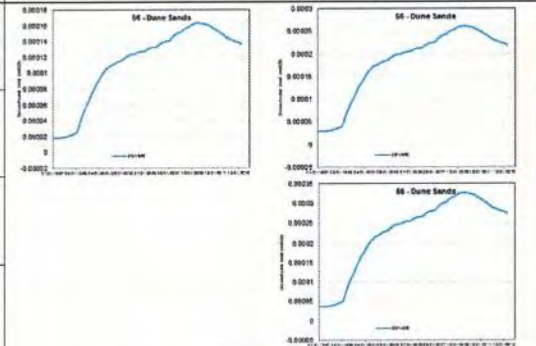
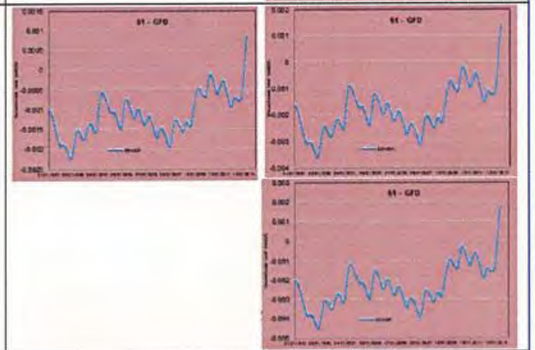
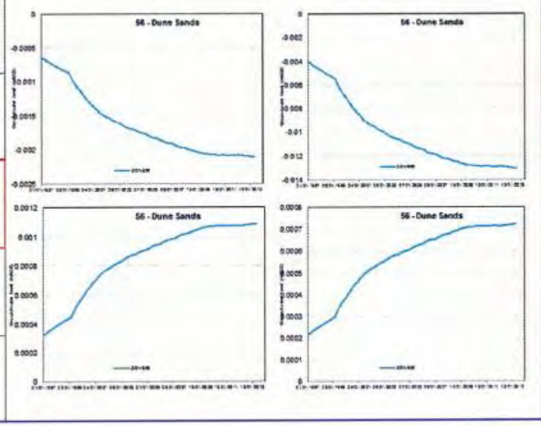
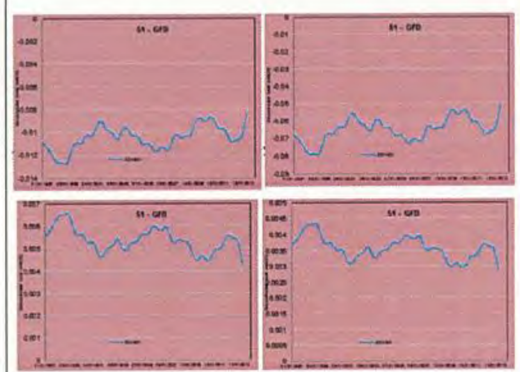
Number	Hydraulic Conductivity (m/d)	Layer Thickness (m)	Transmissivity (m2/d)	Second area Transmissivity (m2/d)	Dune Sands (Graphs in numerical order clockwise from top left)	Glaciofluvial Deposits/Limestone (Graphs in numerical order clockwise from top left)
Calibration	0.00001	3	1.33E-05	-		
7	0.00001	2	4.00E-05	-		
7.1	0.00001	1	7.00E-05	-		
7.2	0.00001	0.5	1.30E-04	-		
Calibration	0.00001	3	1.33E-05	-		
8	0.00001	4	1.25E-05	-		
8.1	0.00001	5	1.20E-05	-		
8.2	0.00001	6	1.17E-05	-		
Calibration	0.0001	8	1.62E-04	-		
9	0.0001	4	2.25E-04	-		
9.1	0.0001	1	5.98E-04			
9.2	0.0001	12	1.42E-04	-		
9.3	0.0001	16	1.31E-04	-		

Table 3.29 Sensitivity analyses results (Runs 10-12)

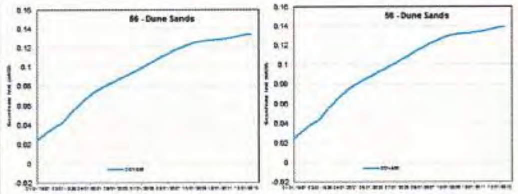
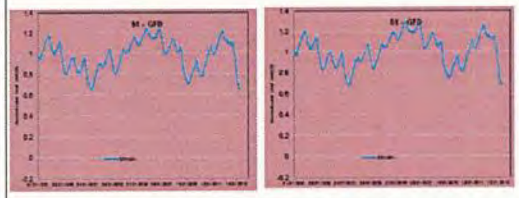
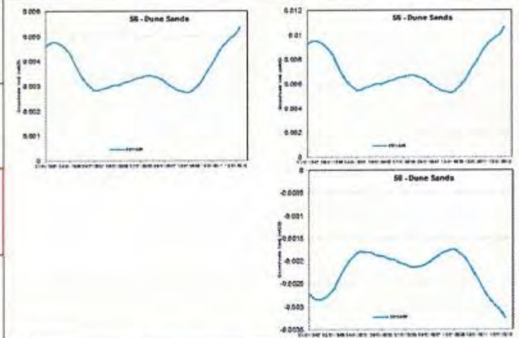
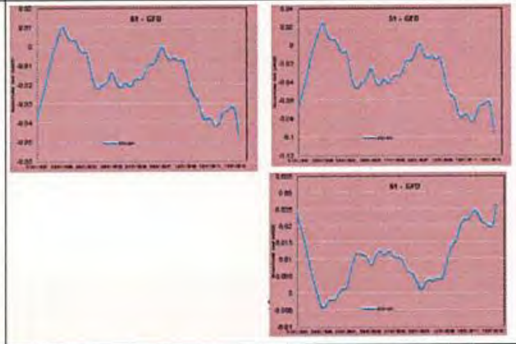
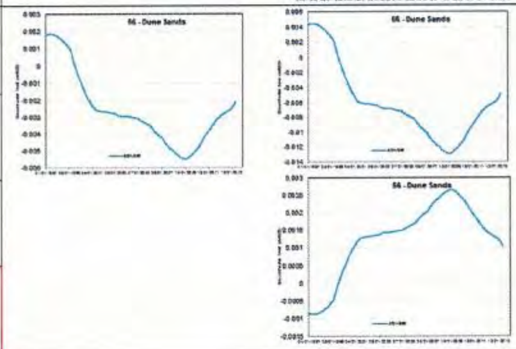
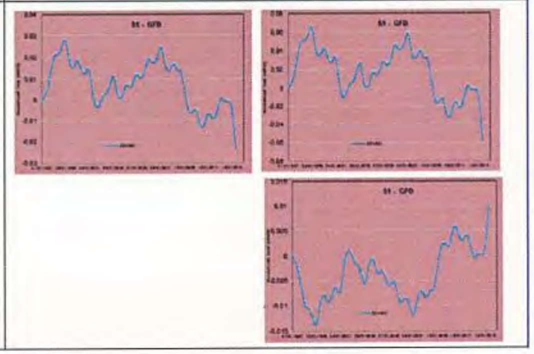
Number	Hydraulic Conductivity (m/d)	Layer Thickness (m)	Transmissivity (m2/d)	Second area Transmissivity (m2/d)	Dune Sands (Graphs in numerical order clockwise from top left)	Glaciofluvial Deposits/Limestone (Graphs in numerical order clockwise from top left)
Calibration	0.0001 (till)	0	1.19E-01	-		
10	0.0001	1	6.00E-05			
10.1	0.0001	8	1.62E-05			
Calibration	0.1	1	1.20E+01			
11	0.1	0.5	1.84E+01	-		
11.1	0.1	0.2	2.72E+01	-		
11.2	1.00E-01	1.5	8.87E+00	-		
Calibration	0.1	1	9.54E+00			
12	0.1	0.5	1.54E+01	-		
12.1	0.1	0.2	2.44E+01	-		
12.2	0.1	1.5	6.93E+00	-		

Table 3.30 Sensitivity analyses results (Runs 13-15)

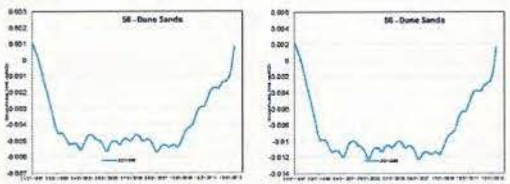
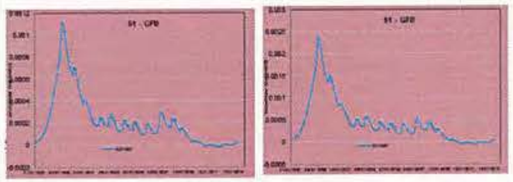
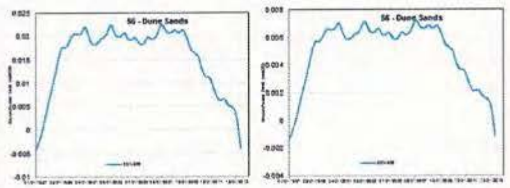
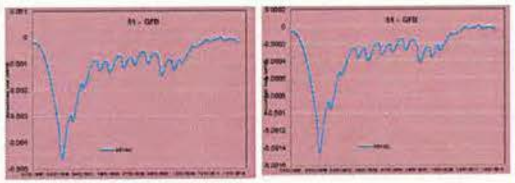
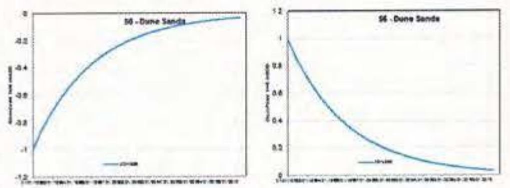
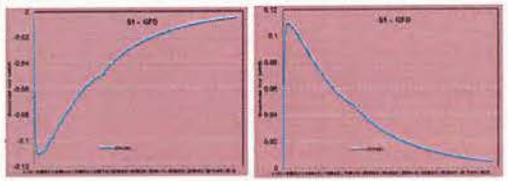
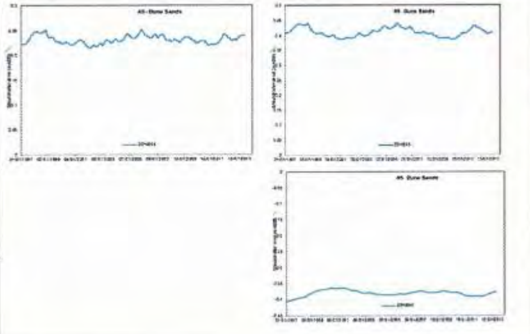
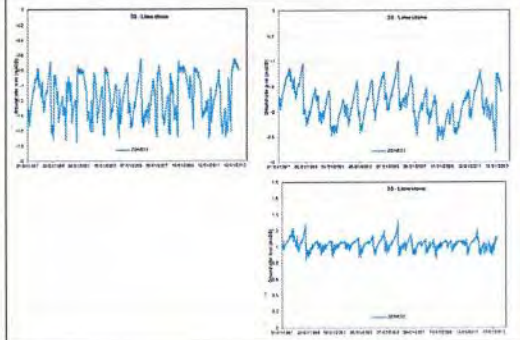
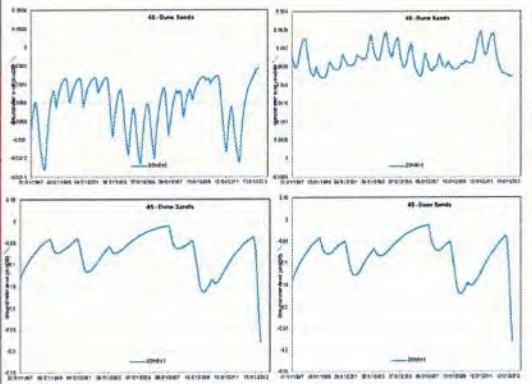
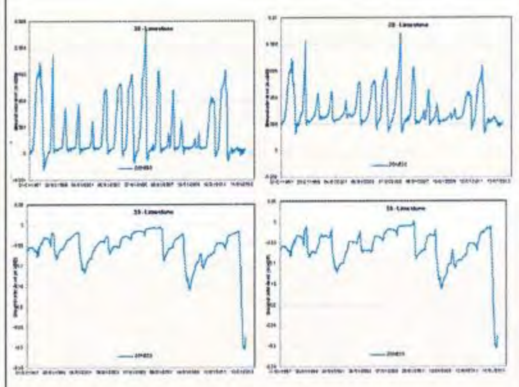
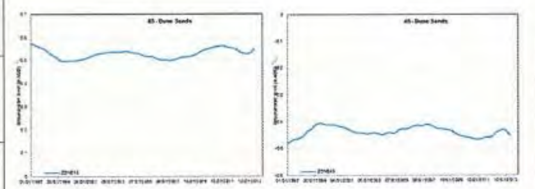
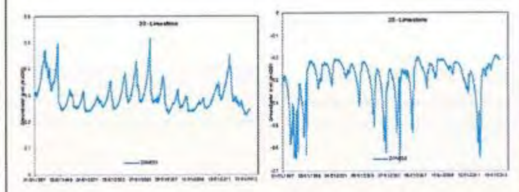
Number	Hydraulic Conductivity (m/d)	Layer Thickness (m)	Transmissivity (m2/d)	Second area Transmissivity (m2/d)	Dune Sands (Graphs in numerical order clockwise from top left)	Glaciofluvial Deposits/Limestone (Graphs in numerical order clockwise from top left)
Calibration	0.1	1	3.55E+01			
13	0.1	1.2	3.15E+01	-		
13.1	0.1	1.5	2.69E+01	-		
Calibration	0.1	1	3.55E+01			
14	0.1	0.5	5.24E+01	-		
14.1	0.1	0.8	4.08E+01	-		
Calibration	Heads 10mAOD					
15	9					
15.1	11					

Table 3.31 Sensitivity analyses results (Runs 16-18)

Number	Hydraulic Conductivity (m/d)	Layer Thickness (m)	Transmissivity (m2/d)	Second area Transmissivity (m2/d)	Dune Sands (Graphs in numerical order clockwise from top left)	Glaciofluvial Deposits/Limestone (Graphs in numerical order clockwise from top left)
Calibration	0.0001	1	7.00E-04			
16	0.0001	1.5	5.00E-04			
16.1	0.0001	2	4.00E-04			
16.2	0.0001	0.5	1.30E-03			
Calibration	5262m2 (cell 42)	27758m2 (cell 43)				
17	2631	27758				
17.2	10524	27758				
17.3	5262	13879				
17.4	5262	41637				
Calibration	Heads 20mAOD	-	-			
18	17					
18.1	23					

4 MODEL PREDICTIVE SCENARIOS

Having derived an acceptable model calibration, the model provides a tool that allows theoretical effects of quarrying activities to be assessed. The model can be used to estimate the difference between groundwater levels and flows for a baseline condition with those levels derived for any relevant quarrying scenario (i.e. the model predictions).

The model set up for the baseline and predictive scenarios are described further in the following sections. Detailed results of the predictive scenarios are described in Appendix 7.4.

4.1 Initial model set-up

The climate sequence and initial conditions uses in the baseline and predictive scenarios are shown schematically on Illustration 4.1 below.

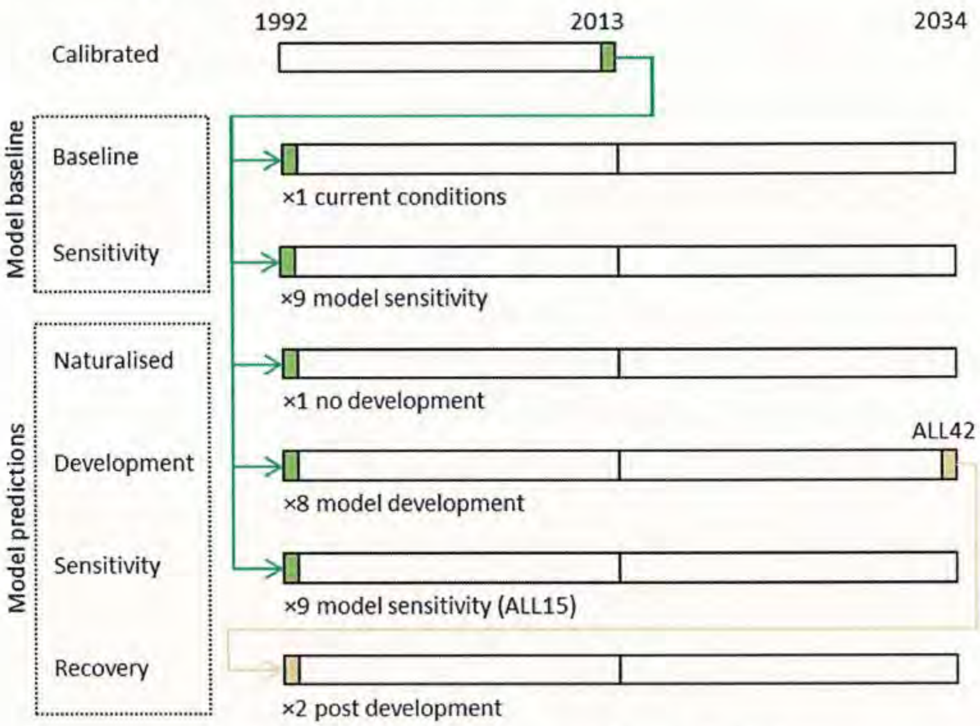


Illustration 4.1 Model baseline and predictive runs

4.1.1 Climate sequence

A future climate sequence for the baseline and predictive scenarios has been constructed from the 21 year climate sequence (1992-2013) used in the calibrated model. In order to extend the climate sequence to cover the full development period (42 years), the 21 year historical sequence has been repeated twice.

4.1.2 Initial conditions

The final heads (1 Jan 2013) from the calibrated model are used to define the initial conditions for the baseline simulation which covers the full 42 year development period. Predictive naturalised and development scenarios have the same climatic sequence and starting heads as the baseline model against which they are to be compared. The recovery model uses the final heads (1 Jan 2034) at the end of development period to see what effect it predicts following quarry development. An equivalent baseline model can be constructed for each set of model parameters brought forward from the formal sensitivity analyses and their predictive runs similarly defined.

4.2 Model Baseline

The model baseline represents the current stage of quarry development against which future development runs can be compared. Cornelly is actively dewatering and the current development depth is constant throughout the simulation at -3 mAOD. It is assumed that all groundwater entering Cornelly quarry sump (Zone 4) is pumped to Grove (Zone 27). Grove and Gaens are not actively dewatering.

4.3 Naturalised run

The naturalised run is a theoretical estimate of what conditions might have been in the absence of any quarry development. Model parameterisation is identical to the calibrated model with the exception that Cornelly sump is deactivated in Zone 4. It does not include the effects of quarry storage.

4.4 Development runs

The groundwater model has been used to carry out predictive simulations for eight development scenarios. The development of the quarries is considered at two future stages;

1) at the end of the 15 year ROMP cycle, and;

2) development at 42 years.

These development stages are undertaken for each quarry in isolation, with two further runs considering the combined development of the three quarries. The development scenarios can be summarised as follows:

- 15 and 42 year development at Cornelly (CN15, CN42)
- 15 and 42 year development at Grove (GR15, GR42)
- 15 and 42 year development at Gaens (GA15, GA42)
- 15 and 42 year development combined (ALL15 and ALL42).

For each development run the sump level for the active quarries at the given stage are set at the appropriate development depths (see Table 4.3). 'No dewatering' indicates that the sump in the respective quarry is set to inactive. The disposal location for Cornelly quarry (Zone 4) operating in isolation is to Grove (Zone 27). Grove in isolation pumps to the railway cuttings (Zone 26) and Gaens (Zone 16) in isolation discharges to the sink holes north-west of the quarry (Zone 23). For the combined development scenarios the discharge location from Grove and Gaens remain the same, whereas Cornelly pumps to Pant Mawr (Zone 7).

4.5 Recovery runs

Recovery modelling was undertaken to simulate effects following the maximum development of all three quarries (i.e. end of run ALL42). Recovery is simulated by ceasing abstraction from the sumps and adding additional storage capacity into the relevant zones to represent open water as the quarry refills (see Table 4.1).

Table 4.1 Additional storage areas in recovery runs

Zone	Elevation (mAOD)	Fractional area (-)	Storage (-)	Description
4	-75.0	0.64	1.0	Cornelly
16	-20.0	0.42	1.0	Gaens
27	-15.0	0.33	1.0	Grove

The additional storage capacity was introduced as discussed in Section 2.8. Quarry areas, as a fraction of each zone, were estimated from development plans.

Initial conditions used in all zones (other than the quarries) are groundwater levels from the end of the combined development run ALL42. Note that the radial flow approximation used to simulate quarry pumping cannot work in reverse (no sump level is defined). As such, inflows to the quarry zones are determined conventionally and would be significantly overestimated if the initial head in the quarry zone were set at the maximum development depths. An iterative approach was adopted to gradually increase the starting heads in each quarry zone to match the radial inflows at the end of the development run ALL42. Initial heads used in the recovery runs in comparison to the final heads from run ALL42 are summarised in Table 4.2.

Table 4.2 Initial quarry heads in recovery runs

Zone	All42 (mAOD)	Recovery (mAOD)	Description
4	-75.0	-10.0	Cornelly
16	-20.0	0.0	Gaens
27	-15.0	0.0	Grove

Two separate recovery models were developed:

1) no mitigation measures are in place, and

2) mitigation with some residual pumping for the initial 10 years of recovery.

- 50% Cornelly pumping rate to the railway springs (1496 m^3/day)
- 50% Grove pumping rate to the railway springs (819 m^3/day)

Additional runs to optimise the mitigation have not been carried out as the final quarry configuration is not yet clear.

4.6 Sensitivity runs

4.6.1 Conceptual and parameter uncertainty

Following the formal sensitivity analysis (Section 3.9), the parameters that were not fully constrained by the model calibration were carried through to the predictive runs. A new baseline scenario is developed for each of these sensitivity runs for the given model parameterisation. The predictive sensitivity runs are all based on the 15 year development run for the combined quarry development (ALL15).

The sensitivity of the simulated changes to model parameterisation (i.e. the difference between the sensitivity run and its sensitivity baseline compared with the difference between the ALL15 run and the main baseline run) are subsequently assessed.

4.6.2 Model equivalence

In addition to conceptual and parameter uncertainty, there remains a level of uncertainty due to model equivalence regarding the calibrated values for recharge and transmissivity. Recharge and transmissivity are influential model parameters and an approach is required to fully examine the likely range to which transmissivity has been constrained. .

An agreed upon approach has been to undertake two sensitivity runs with an increase and decrease in recharge throughout the model by 15% (this is the largest change in recharge relative to the best estimate that is considered to be credible). To ensure that groundwater heads are maintained at their approximate calibration position, the transmissivity was also increased and decreased by 15% throughout the respective models. This therefore provides sensitivity analysis with the highest and lowest transmissivity broadly consistent with the current conceptual model.

4.6.3 Burrows Well

A further sensitivity analysis was undertaken to investigate the adequacy of the model representation at Burrows Well (see Section 3.7.2).

For the calibrated model, the simulated flows were compared to the observed flows at Burrows Well and a fourth order polynomial fitted to the data (see Illustration 4.2).

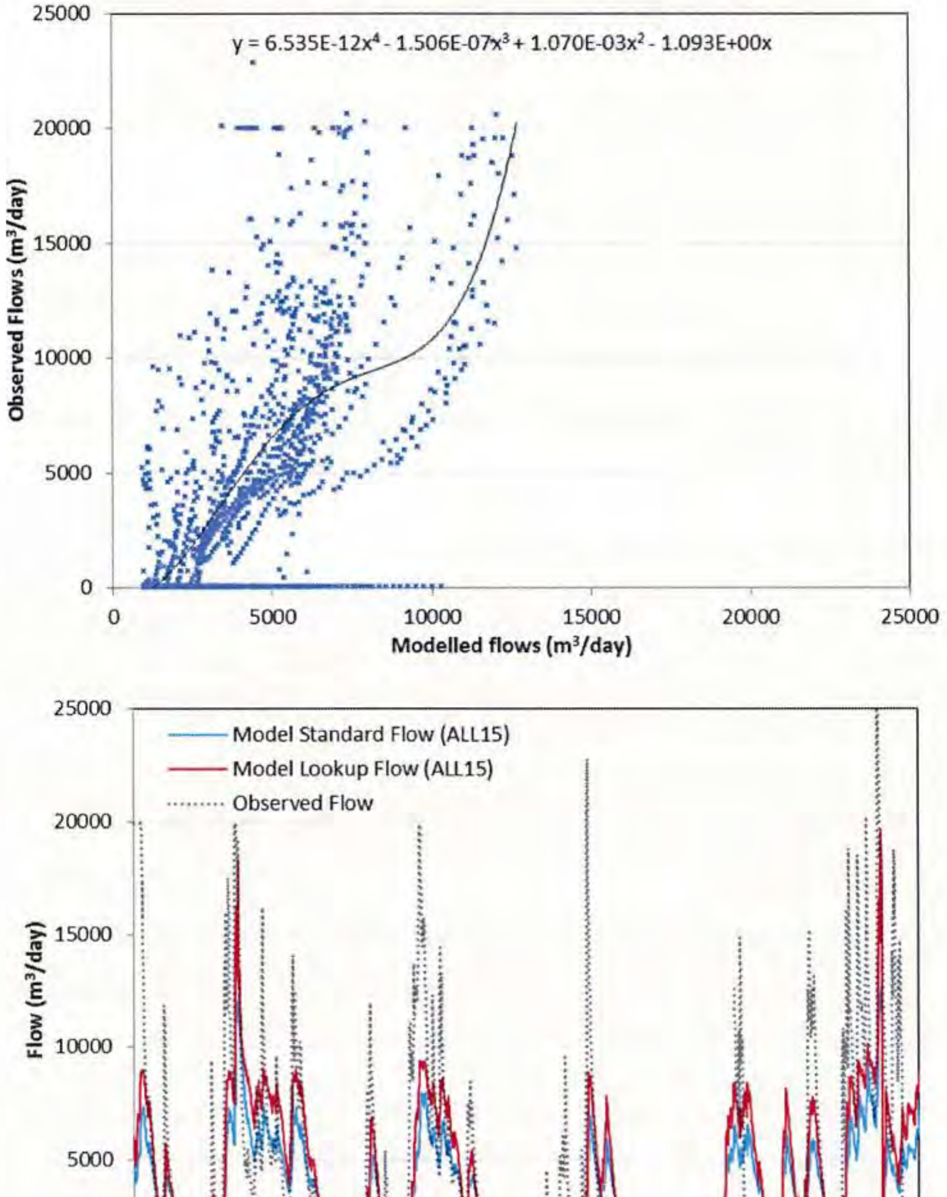


Illustration 4.2 Modelled vs Observed for Burrows Well flows lookup function

The polynomial then is used as a lookup function to transform the simulated flows at Burrows well under revised versions of the Baseline and ALL15 development runs into a data sequence that is more consistent to the observed values. That is, the model value (x) is replaced with the transformed value (y) used subsequently as the discharge at Burrow Well (note that the function is truncated where it crosses zero on the y-axis; modelled flows below 1300 m^3/day are transformed to 'no flows').

Although this potentially creates an overall imbalance in the model water balance (i.e. where water is added or subtracted according to the lookup function), the principle concern is with the relative changes in simulated water levels downstream in the Blown Sands at Merthyr Mawr. In this way an assessment can be made as to whether the relative changes between Baseline and Development runs using an improved representation of flows from Burrows Well are more or less than those simulated using the standard representation.

Whilst the results of the standard predictive run sensitivity analysis are presented in Appendix 7.4, it is more appropriate to discuss this specific issue here in terms of overall model credibility.

Illustration 4.3 shows the effect of transforming Burrows Well flows on the predicted change in water levels in the Blown Sand cells at Merthyr Mawr under the All15 development scenario (i.e. v. Baseline).

The average post development difference in water levels between the calibrated model and the sensitivity run with the Burrows Well function is set out in Table 4.3. This shows that using the Burrows Well flow function increases the simulated effect of the proposed development (i.e. All15 v. Baseline) by between 13 and 17%. This is considered to be small relative to the uncertainties in the whole assessment process and suggests that, whilst the calibration of flows at Burrows Well is not ideal, this is unlikely to affect the overall conclusions of the assessment. This constrained level of uncertainty has been taken forward into the overall assessment.

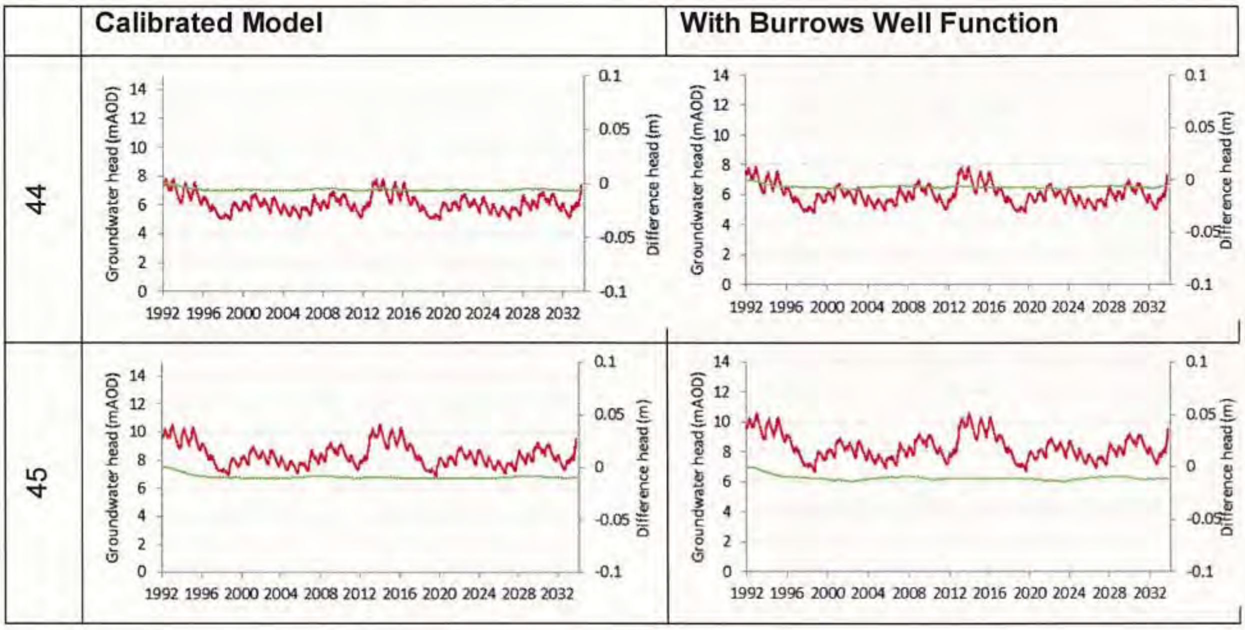


Illustration 4.3 Effect of using Burrows Well flow function on simulated post development change in water levels

Cell	Calibrated Model	With Burrows Well Function	% difference
44	-0.0058	-0.0068	17%
45	-0.0093	-0.0105	13%

Table 4.3 Model prediction runs

Run	Description	Run Type	Stage (year)	Development depth (mAOD)			Starting Heads	Disposal locations
				Cornelly	Grove	Gaens		
1	Baseline	Baseline		-3	no dewatering	no dewatering	1st Jan 2013 CA	Cornelly ⇔ Grove
2	CN15	Development	15	-30	no dewatering	no dewatering	1st Jan 2013 CA	Cornelly ⇔ Grove
3	CN42	Development	42	-75	no dewatering	no dewatering	1st Jan 2013 CA	Cornelly ⇔ Grove
4	GR15	Development	15	-3	-15	no dewatering	1st Jan 2013 CA	Cornelly ⇔ Pant Mawr : Grove ⇔Railway Cutting
5	GR42	Development	42	-3	-15	no dewatering	1st Jan 2013 CA	Cornelly ⇔ Pant Mawr : Grove ⇔Railway Cutting
6	GA15	Development	15	-3	no dewatering	0	1st Jan 2013 CA	Cornelly ⇔ Grove : Gaens ⇔NW
7	GA42	Development	42	-3	no dewatering	-20	1st Jan 2013 CA	Cornelly ⇔ Grove : Gaens ⇔NW
8	ALL15	Development	15	-30	-15	0	1st Jan 2013 CA	Cornelly ⇔ Pant Mawr : Grove ⇔Railway Cutting : Gaens ⇔NW
9	ALL42	Development	42	-75	-15	-20	1st Jan 2013 CA	Cornelly ⇔ Pant Mawr : Grove ⇔Railway Cutting : Gaens ⇔NW
10	Combined recovery	Recovery	-	-	-	-	1st Jan 2034 ALL42	-
11	SENS1	Sensitivity	-	-30	-15	0	1st Jan 2013 S1	Cornelly ⇔ Pant Mawr : Grove ⇔Railway Cutting : Gaens ⇔NW
12	SENS2	Sensitivity	-	-30	-15	0	1st Jan 2013 S2	Cornelly ⇔ Pant Mawr : Grove ⇔Railway Cutting : Gaens ⇔NW
13	SENS3	Sensitivity	-	-30	-15	0	1st Jan 2013 S3	Cornelly ⇔ Pant Mawr : Grove ⇔Railway Cutting : Gaens ⇔NW
14	SENS4	Sensitivity	-	-30	-15	0	1st Jan 2013 S4	Cornelly ⇔ Pant Mawr : Grove ⇔Railway Cutting : Gaens ⇔NW
15	SENS5	Sensitivity	-	-30	-15	0	1st Jan 2013 S5	Cornelly ⇔ Pant Mawr : Grove ⇔Railway Cutting : Gaens ⇔NW
16	SENS6	Sensitivity	-	-30	-15	0	1st Jan 2013 S6	Cornelly ⇔ Pant Mawr : Grove ⇔Railway Cutting : Gaens ⇔NW
17	SENS7	Sensitivity	-	-30	-15	0	1st Jan 2013 S7	Cornelly ⇔ Pant Mawr : Grove ⇔Railway Cutting : Gaens ⇔NW
18	SENS8	Sensitivity	-	-30	-15	0	1st Jan 2013 S8	Cornelly ⇔ Pant Mawr : Grove ⇔Railway Cutting : Gaens ⇔NW
19	SENS9	Sensitivity	-	-30	-15	0	1st Jan 2013 S9	Cornelly ⇔ Pant Mawr : Grove ⇔Railway Cutting : Gaens ⇔NW

5 REFERENCES

ESI, 2003 6227R5 Cornelly Group of Quarries: Conceptual Model of the Local Hydrogeology.

ESI, 2004 6227R6 Cornelly Group of Quarries: Hydrogeological Impact Assessment for Cornelly Quarry and Combined Quarries

Jones, P. S., 1993 Ecological and hydrological studies of dune slack vegetation at Kenfig NNR. Unpubl. PhD thesis. University College, Cardiff

Schlumberger Water Services (SWS), 2010 Refining river basin planning through targeted investigations on selected welsh groundwater dependent terrestrial ecosystems (GWDTES)

WynThomasGordonLewis, 2004. Environment Act 1995: Review of Mineral Planning permissions Cornelly Quarry.

FIGURES

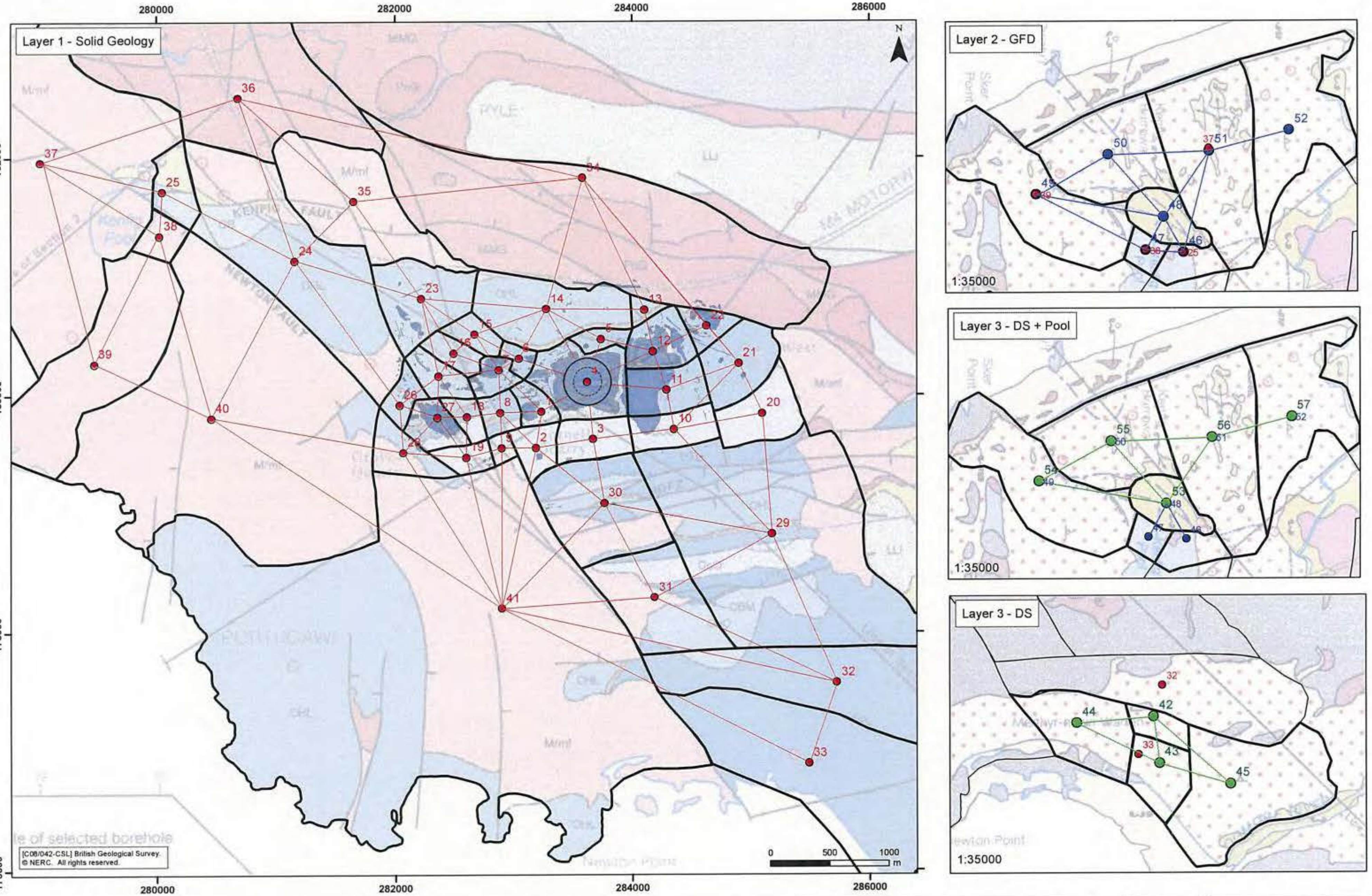


Figure 2.1
Model zones and connections

Date	Drawn
Jan 2014	SRA
Scale 1:30,000	Checked BCH
Original A3	Revision 1

File Reference
O:\6227_Cornelly\reports\R17 EIA\Appendix 7.3 Groundwater Modelling Report\Figures\Figure 2.1 Model zones & connections.mxd

esi Environment Specialists

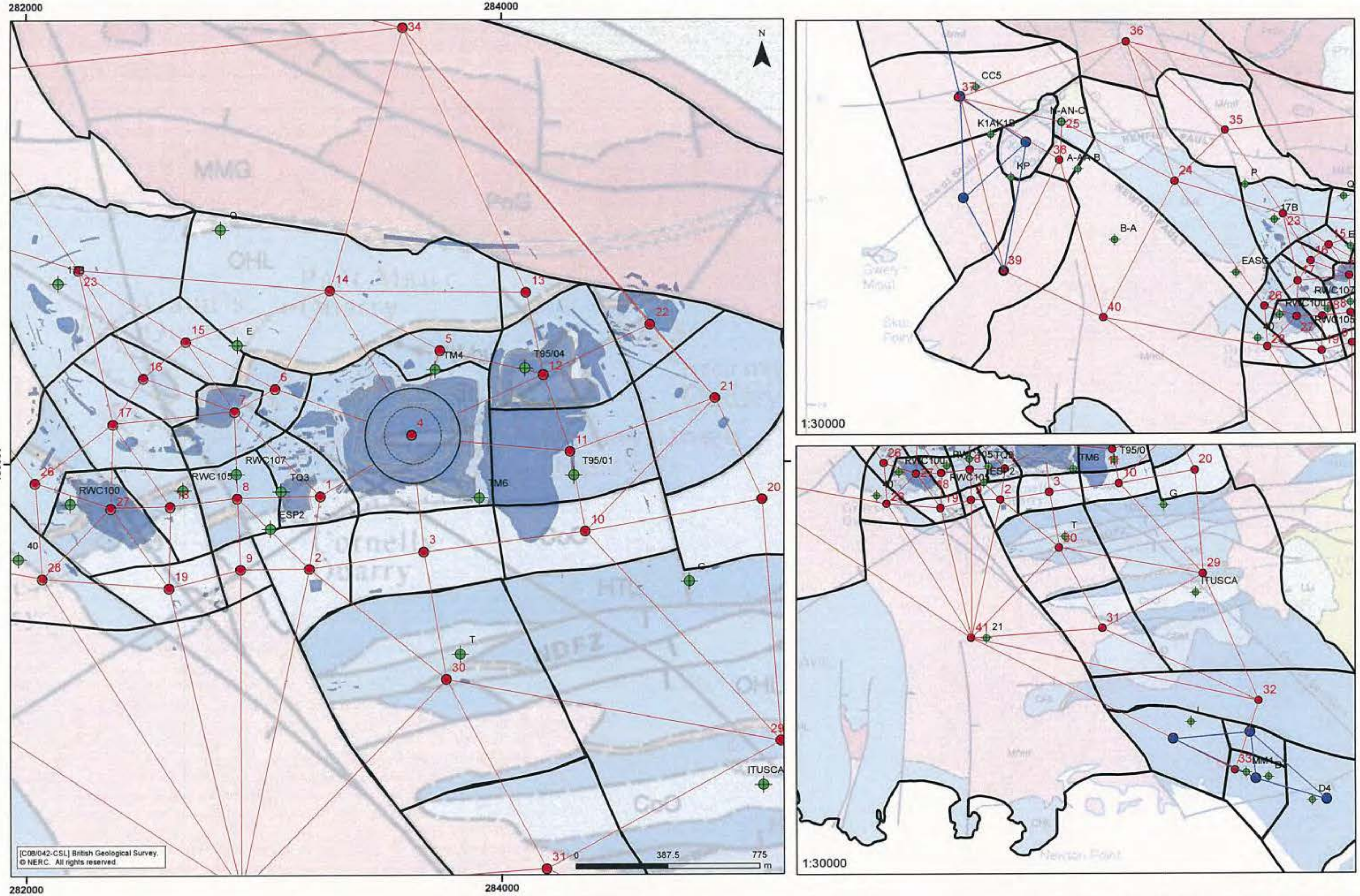


Figure 3.1
Locations of calibration boreholes

Date	Drawn
Jan 2014	SRA
Scale	Checked
1:15,000	BCH
Original	Revision
A3	1

File Reference
O:\6227_Cornelly\reports\R17 EIA\Appendix 7.3 Groundwater Modelling Report\Figures\Figure 3.1 Calibration BH Locations.mxd

esi
Environment Specialists

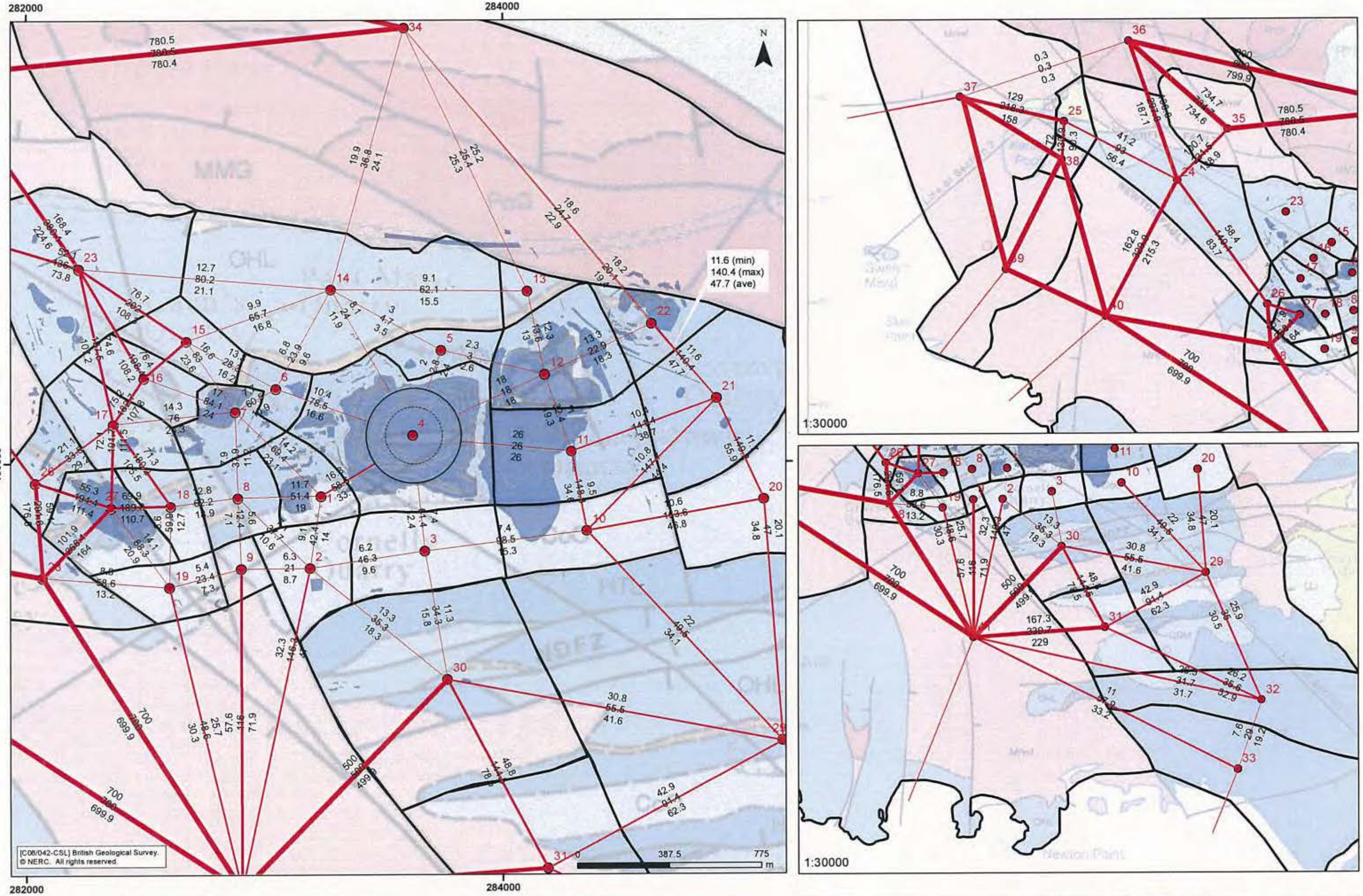


Figure 3.2
Solid geology calibrated transmissivity values

Date	Drawn
Jan 2014	SRA
Scale 1:15,000	Checked BCH
Original A3	Revision 1

File Reference

Environment Specialists

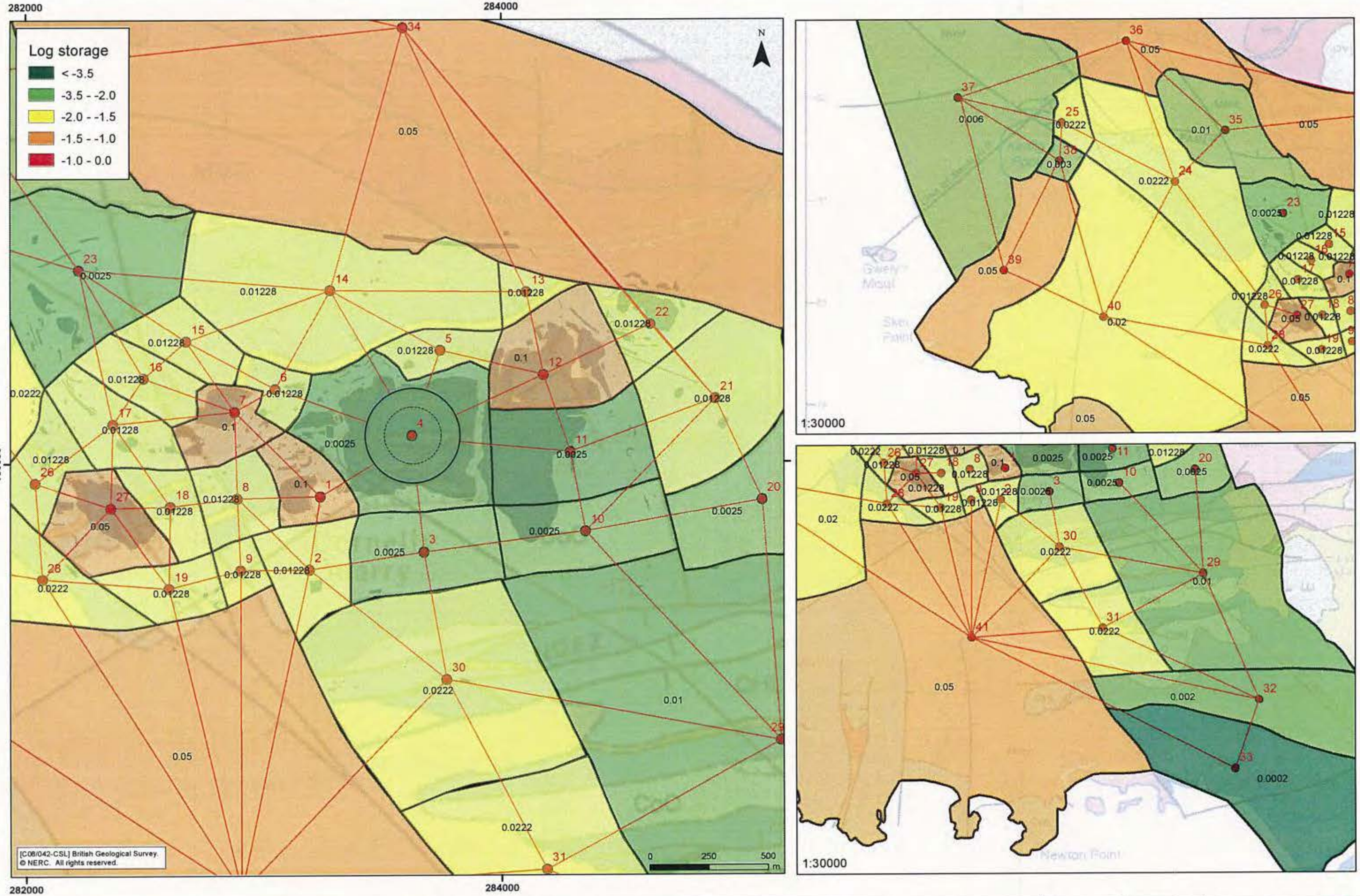


Figure 3.3
Solid geology calibrated storage values

Date	Drawn
Jan 2014	SRA
Scale	Checked
1:15,000	BCH
Original	Revision
A3	1

File Reference
O:\6227_Cornelly\reports\R17 EIA\Appendix 7.3 Groundwater Modelling Report\Figures\Figure 3.3 Calibration Solid Geology S.mxd

esi Environment Specialists

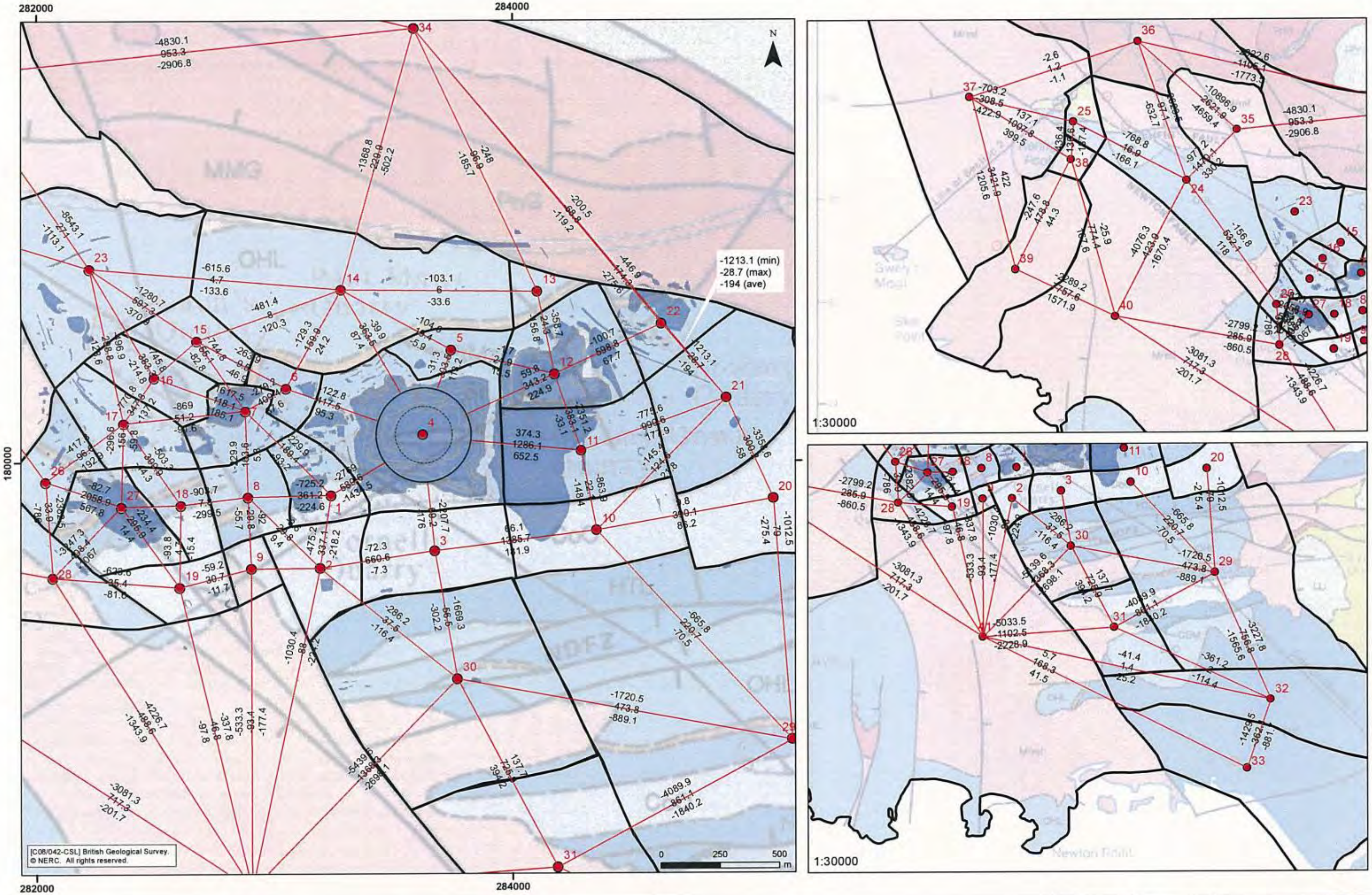


Figure 3.4
Solid geology lateral groundwater flows

Flows direction assumes Zone From < Zone To
+ve values indicate inflow
-ve values indicate outflow

Date: Jan 2014	Drawn: SRA
Scale: 1:15,000	Checked: BCH
Original: A3	Revision: 1

File Reference
O:\6227_Cornelly\reports\R17 EIA\Appendix 7.3 Groundwater Modelling Report\Figures\Figure 3.4 Calibration Solid Geology Q.mxd

esi
Environment Specialists

Appendix F Summary of Results of Hydrogeological ES for Gaens Quarry

F.1 Conceptual Model

A comprehensive, updated conceptual model is presented in Appendix 7.1 of the Environmental Statement for Cornelly Quarry (SLR, 2014) and summarised in this section.

The Cornelly Group of quarries work Carboniferous Limestone that forms part of a wider, inter-connected aquifer system extending over an area of around 25 km^2 (see Figure 6.1 of Appendix 7.1). This is bounded by the River Kenfig to the north, the River Ogmore to the south, by various faults to the north east and by the coast to the south and west.

The Carboniferous Limestone forms the main, karstic aquifer in this area but is overlain by permeable, layered and possibly karstic, Triassic strata to the west and south. The Blown Sands at Kenfig and Merthyr Mawr form minor aquifers that have a degree of connection with the underlying Carboniferous/Triassic aquifers.

Groundwater discharge from the limestone aquifer occurs as follows:

- Along the ~10 km of coastline that forms the western and southern boundaries of the area. This accounts for around 70% of the total discharge;
- At the large springs at New Mill Farm;
- Within the Blown Sand dunes at Kenfig and in Kenfig Pool;
- At the large spring at Burrows Well;
- Pumping from Cornelly Quarry (and occasionally from Grove and Gaens Quarries). This water is all re-circulated back into the limestone and is therefore not lost to the system.

The following sections describe the conceptual model of some of the key parts of this system in more detail.

<u>Cornelly Group of Quarries</u>

Over a period of ~30 years groundwater levels at Cornelly have been reduced by a total of around 60 m over an area of around 0.5 km^2. Average inflows to the quarry sump are only ~3,500 m^3/d and the off-site pumping rate is only around 2,000 m^3/d - equivalent to a catchment area of less than 1 km^2.

The low transmissivity of the aquifer in this area is due to a combination of stratigraphical, structural and erosion/dissolution processes.

The present phase of karst development/re-activation in the limestone at Cornelly extends down about 40 m from the surface. The dewatered saturated zone appears to be characterised by diffuse fracture flow rather than a karst conduit network. This suggests that there is a low probability of the further deepening of Cornelly quarry encountering significant zones of enhanced permeability at depth.

The extent of active karst in Gaens and Grove quarries is less clear as these quarries are smaller and have not been worked to such depths.

Groundwater gradients to the west of the Newton Fault are generally flatter than to the east, implying a much lower transmissivity in the latter area.

<u>New Mill Springs</u>

New Mill Springs form an important discharge point for the northern part of the Carboniferous Limestone/Triassic aquifer system. The total gain in the River Kenfig in this area is consistent with a catchment area of 8.8 km^2.

Kenfig Pool and Dunes

The groundwater system at Kenfig comprises three aquifers: the Blown Sand dunes, and the underlying glaciofluvial gravels and Carboniferous/Triassic aquifers.

The eastern boundary of the saturated Blown Sand aquifer follows the eastern boundary of Kenfig Pool northwards to the remains of Kenfig castle and south west out to Sker point. A laterally extensive low permeability estuarine clay layer below the sands limits the hydraulic connection between the sands and the underlying aquifers.

Groundwater flows from a groundwater high north west of Kenfig Pool westwards towards the coast, north to the River Kenfig and south east to Kenfig Pool. Groundwater level and hydrochemical data imply that recharge from rainfall over the site provides the great majority of flow in the system.

The underlying gravels form a minor, confined aquifer. Groundwater level trends are similar (albeit subdued) compared to the underlying Triassic strata suggesting a degree of connection. Fluctuations are much larger than within the Blown Sands and the hydraulic gradient is downwards except in very wet periods. This indicates that these two aquifers are not well connected. Comparison of gravels groundwater levels with Kenfig Pool levels implies that this aquifer system discharges towards the coast rather than upwards through the sands.

Merthyr Mawr

There are two distinct hydrogeological units at Merthyr Mawr – the Blown Sand superficial deposits at surface and the underlying Carboniferous Limestone. A degree of hydraulic separation between the two units is provided by a clay layer which appears to be present across the majority of the site and is typically more than 0.5 m thick.

A step in the underlying limestone separates the Blown Sand deposits into two topographic levels: an area at lower elevation, within which the dune slacks form, adjacent to the sea and an area at higher elevation further inland which is considered to be largely dry.

Limestone water levels are generally below those in the sand, however, due to a higher degree of fluctuation there are times when the limestone aquifer water levels are higher than the sand levels and the gradients are reversed. Burrows Well spring discharges during periods of high limestone groundwater level

In the area to the south of Burrows Well, water levels are affected by the discharge of limestone groundwater levels into the Blown sands which causes large areas to pond, possibly on a shallow clay layer in this area (SWS, 2010). When the spring stops flowing, these water levels drop rapidly by three or more metres (e.g. piezometer D7) i.e. the groundwater system in this area is not typical of dune slacks more generally.

There are three main inputs to the groundwater system in the sands: direct recharge, runoff from less permeable catchments to the north east and intermittent flow from the underlying Carboniferous Limestone that discharges at Burrows Well. Groundwater flow in the limestone and Blown Sand aquifer is southwards towards the sea.

Water Balance

The following conclusions regarding water balance have been drawn from the work carried out:

- Almost all of the flow in the Blown Sands at Kenfig is sourced from direct rainfall (2% from surface water inflow). This flow leaves the system by a mixture of groundwater flow and overland flow via the slacks with a very small component of downwards leakage into the underlying sands and gravels.
- New Mill Farm springs appears to account for all of the water recharging to the Carboniferous Limestone and Triassic marginal facies aquifers in the northern part of the study area.

- The diffuse nature of coastal outflows around Porthcawl mean that the water balance is not as good.
- 45% of the total inflow to the Blown Sand system comes from Burrows Well discharge with the remainder being sourced by direct recharge. The majority flows to the sea; around 14% leaks downwards to the underlying limestone.

F.2 Summary of Results of Impact Assessment

This section contains a summary of the results of the hydrogeological impact assessment for Gaens Quarry (SLR, 2014 Chapter 7). This is provided to assist cross reference between the WMP and the ES. For further detail on the approach used etc., the original report should be used.

F.2.1 Approach

The assessment is based on the standard *source-pathway-receptor* approach and is sub-divided into a number of steps:

1. Identification of receptors
2. Identification of pathways
3. Quantification of effects
4. Assessment of significance/impact

A number of critical thresholds have been set to screen out those effects which may be significant from those that aren't:

- Licensed groundwater abstraction boreholes - predicted groundwater level reduction in excess of 0.5 m
- Shallow wells - predicted groundwater level reduction in excess of 0.25 m.
- Ponds (excluding Kenfig Pool and any dune slacks in Kenfig Pool and Dunes and Merthyr Mawr SAC) - predicted groundwater level reduction in excess of 0.1 m.
- Spring flows - derogation of flow in excess of 10% of mean long term flows.

Degree of impact is assessed through consideration of the degree of effect and the importance of the receptor as summarised in the table below:

		Receptor Value		
		Low	**Medium**	**High**
Degree of effect	**Negligible**	Negligible	Negligible	Negligible
	Low	Minor	Minor	Moderate
	Medium	Minor	Moderate	Major
	High	Moderate	Major	Major

For reporting purposes effects/impacts are presented in four separate categories A to D as shown in the following section.

F.3.2 Results

(A) General effects on groundwater levels and flows – this is taken to include the assessment of the potential impacts on the water resources of the Swansea Southern Carboniferous Limestone groundwater (Water Framework Directive) body;

Quarry development generally results in decreased groundwater levels in the immediate vicinity of the quarries but these effects dissipate quickly with distance from the quarry. Recovery results in temporary decreases away from the quarry as water fills storage within the quarry voids. In some areas recovered levels are slightly higher and in other areas they are slightly lower due to the removal of the effects of quarry dewatering discharge.

Impacts are **Negligible** for individual development, combined development, and recovery conditions

(B) Potential effects on water levels in the dune sands at Kenfig Pool and Dunes SSSI and the Merthyr Mawr SSSI

Water levels fall slightly at Kenfig under all development scenarios and during recovery. Stabilised recovered levels remain lower than current. The largest change in water levels at Kenfig is seen during recovery with a temporary drop of up 12 cm in the dunes to the east of Kenfig Pool. Mitigation reduces this below the 10 cm critical threshold. Changes in other dune cells and for other scenarios are not more than 1 cm. Hydrogeological impact is **Negligible**.

Water levels at Merthyr Mawr decline under all development scenarios and during the initial stages of recovery. Stabilised recovered levels and flows remain higher than current. The largest changes in level and flow at Merthyr Mawr are seen during recovery. Representative Blown Sand aquifer cells at Merthyr Mawr show no more than 3.5 cm reduction under all scenarios. Flows at Burrows Well do not exceed 5% peak reduction under all scenarios. Hydrogeological impact is **Negligible**.

(C) Potential effects on water levels and flows at other receptors

The largest changes in level and flows are seen during recovery.

Drawdowns in excess of the critical threshold are seen at:

- Royal Porthcawl Golf Club well (Loc. 14)
- Ty Tanglwyst Farm pond (Loc. 17)
- Ty Tanglwyst Farm well (Loc. 17a)
- Ty Talbot Farm, Nottage (Loc. 18b)
- Wilderness Pond (Loc. 20)
- The well at White Wheat (Loc. 21)
- Pwll y Waun pond (Loc. 23)
- The well at Home Wood (Loc. 33)
- The pond at location 34 (Loc. 34)
- Royal Porthcawl Golf Club well (Loc. 36)
- Grove Golf Club well (Loc. 40)
- Tynycaeau (Loc. 61)
- Pyle & Kenfig Golf Course (Loc. 65)

Of these, hydrogeological conditions mean that only Grove Golf club has **Moderate adverse** impact with the remainder considered **Minor adverse**.

Effects at springs vary depending on location and scenario. At New Mill Farm springs the greatest reductions in flow are seen during recovery. Short term flows initially exceed 10% reduction but flows increase over the recovery period. Impacts at springs are either **Negligible** or **Minor adverse** under all scenarios.

(D) Other potential effects

There is a relative increase in flows toward Cornelly Quarry from Stormy West landfill under all scenarios but the magnitude of flows is small. At Tythegston flows are always away from the quarries.

There are no ground stability effects.

Flows toward the coast are most reduced under in the recovery run where a maximum reduction of just under 9% is predicted.

Appendix E

Abstraction calculations worksheet

(Electronic appendix)