CAULMERT LIMITED

Engineering, Environmental & Planning

Consultancy Services

Sundorne Products (Llanidloes) Ltd

BRYN POSTEG LANDFILL SITE (EPR/BU7766IC)

Surface Water Pollution Risk Assessment

Prepared by:

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Doc ref 3400-CAU-XX-XX-RP-O-0302.A0.C3

Issue date: 1st March 2021

APPROVAL RECORD

Site:	Bryn Posteg Landfill Site
Client:	Sundorne Products (Llanidloes) Ltd
Project Title:	Surface water discharge treatment Assessment
Document Title:	Surface Water Pollution Assessment – H1
Document Ref:	3400-CAU-XX-XX-RP-O-0302.A0.C3
Report Status:	Final for issue
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Reviewer	Andy Stocks	**Date**	01/03/2021
Approved	Andy Stocks	**Date**	01/03/2021

DISCLAIMER

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1 SURFACE WATER POLLUTION RISK ASSESSMENT OF TREATED SURFACE WATER FROM LAGOON 3 AT BRYN POSTEG LANDFILL SITE

1.1 Background

1.1.1 Sundorne Products (Llanidloes) Limited (hereafter referred to as the 'Operator') have instructed Caulmert Limited to undertake a surface water pollution risk assessment associated with the discharge of treated surface water from Lagoon 3 at Bryn Posteg Landfill Site.

1.1.2 The surface water treatment system has been designed to enable the installation of a surface water treatment system comprising a series of balancing ponds, dosing and flocculation plant and silt traps to reduce the suspended solids to within the current discharge.

1.1.3 The maximum capacity of the plant will be designed to treat 30 l/s, although balancing ponds are proposed to manage the peak runoff. This report aims to assess the potential pollution risk as a result of the proposed treatment system and includes the assessment of the parameters currently stipulated within the Environmental Table S3.3 within the Permit EPR/BU7766IC issued 16/10/17.

1.1.4 The surface water pollution risk assessment reviews the potential impact from the introduction of chemicals / flocculants used within the treatment process together with the permitted discharge quality. This report has been produced following preliminary discussions between the Operator and NRW with respect to the potential treatment options and the requirement to assess the pollution risk to surface water.

1.1.5 The report follows the methodology set out in the online guidance* on surface water pollution risk assessment which NRW has indicated remain applicable in Wales.

* https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit

2 STAGE 1: IDENTIFY THE POLLUTANTS RELEASED FROM YOUR PLANT

2.1.1 The proposed surface water treatment facility at Bryn Posteg is designed specifically to enhance the flocculation and precipitation of silt during the treatment process. A number of additives have been considered during the trials including aluminium chloride, ferric chloride and Aquatreat 256 and Aquatreat 156. It is understood that during initial discussions with NRW the preferred option included aluminium chloride.

2.1.2 All additives achieved the desired effect of reducing suspended solids within the surface water samples. In reviewing the potential risks to the surface water environment, the potential additives for the treatment system were reviewed against the materials safety data sheets (Appendix 1) with respect to hazard codes and the environmental water quality standards for the active ingredients.

2.1.3 Following this review the preferred treatment system at Bryn Posteg will rely on ferric chloride rather than aluminium chloride as a flocculant.

2.1.4 Two patented chemicals proposed to enhance the chemical treatment were considered: Aquatreat 256 and Aquatreat 156. Aquatreat 156 has been chosen over Aquatreat 256 as it contains no hazardous materials in accordance with the provided Materials safety data sheet (Appendix 1).

2.1.5 Due to the commercial sensitivity, the chemical make-up of Aquatreat 156 is unknown however the material data sheet states that this has no hazard ratings. It also states that the material decomposes to ammonia, carbon oxides and nitrogen oxides. It is therefore considered that any impact from this compound would be regulated by the existing ammoniacal nitrogen limit on the discharge. The potential pollution risk for Aquatreat 156 is therefore not considered directly but is included within the assessment of ammoniacal nitrogen.

2.1.6 The quality of the surface water runoff from the site is monitored in accordance with the environmental permit and as such it is not proposed to vary the monitoring parameters.

2.1.7 Therefore the likely pollutants to be released as part of the discharge will comprise:

- Parameters limited as part of the Environmental Permit:
  - Ammoniacal nitrogen,
  - pH,
  - BOD, and
  - Suspended solids:
- Ferric chloride
- Aquatreat 156

2.1.8 The current limits on the discharge of surface water from the site are presented in Table 1 below:

Table 1: Current limits on discharge of surface water (P1)

Determinand	Units	Point Source Emissions Limit
Ammoniacal Nitrogen as N	mg/l	0.25
pH	pH Units	6-9
BOD, unfiltered	mg/l	20
Suspended solids	mg/l	50

3 STAGE 2 GATHERING DATA

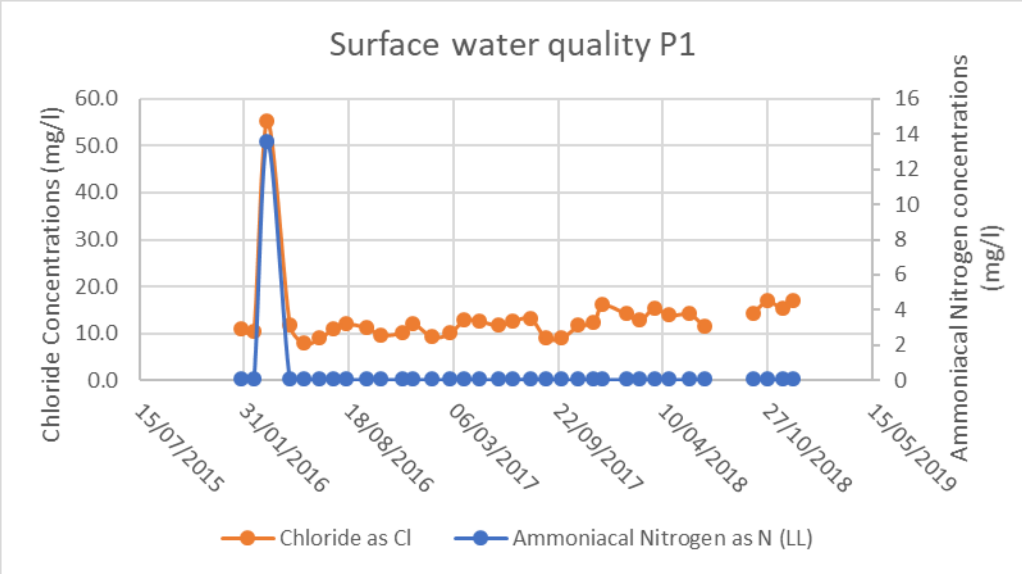
3.1.1 The guidance requires a number of parameters to be gathered prior to being able to complete the screening assessment. It is noted that this proposed discharge is likely to vary with time and particularly in response to rainfall events. Therefore, until the system is operational information such as average discharge volumes are unknown, the assessment is based on the maximum treatment volumes. The required data is detailed in Table 2 below:

Table 2: Discharge and receiving water data

	Chemical name	Ammoniacal nitrogen as n	pH	BOD	Suspended solids	Iron	Aquatreat	Justification
Units		mg/l	-	mg/l	mg/l	mg/l	-	
Discharge (2016 - 2018 site data)	Min	0.1	6.2	1.0	1.0		N/A	No data for iron – back calculation to determine acceptable concentration See below for site data
	Average	0.1	6.9	1.6	8.2			
	95%ile	0.1	7.5	4.0	30.0			
	Max	13.6	7.8	10.0	38.0			
	Count	34	34	34	34			
Emissions limits		0.25	6-9	20	50			
Maximum flow l/s		30l/s						Maximum treatment rate
Average flow l/s								No average flow data
Fresh water upstream	Maximum conc	0.3	7.3	3.5		10.8	N/A	See below
	Average conc	0.2	6.6	2.2		5.18		
	Min conc	0.1	5.8	1		0.6		
LOD		0.06		1				
EQS	Annual average	ND	ND	ND	ND	1.0		Fresh water
	MAC	ND	6-9	20*	ND	ND		Fresh water

ND - not determined / available, NA Not applicable, * taken to be the emissions limit in the absence of a published standard

3.1.2 Routine surface water monitoring data is undertaken at P1 located at the discharge point of the eastern catchment. This data indicates that with the exception of an event occurring in early 2016, the contaminant concentrations are low (data is contained in Appendix 2)



3.1.3 The data collected from this event has been excluded from the calculation of the average and 95%ile values in the table above. All concentrations below the laboratory detection limit of 0.06 mg/l for ammoniacal nitrogen have been taken to be at this detection limit within the graph above.

3.1.4 The environmental water quality standard for ammoniacal nitrogen as NH4 (0.5mg/l) has been withdrawn and therefore the Water Framework Directive classification standards have been used as an indication of background water quality.

Table 1.1: Standards for ammonia				
Total Ammonia (mg/l) (annual 90-percentile)				
Type of river	High	Good	Moderate	Poor
Upland and low alkalinity	0.2	0.3	0.75	1.1
Lowland and high alkalinity	0.3	0.6	1.1	2.5

3.1.5 The discharge from the Lagoon 3 ultimately discharges to and comprises the headwaters of the Nant y Bradnant and therefore there are no upstream concentrations available. In absences of such data, it is considered appropriate to use historic data collected prior to the development of the landfill site to present natural surface water and groundwater quality within this catchment. It is noted that this is spot data.

3.1.6 This information predating the development of the landfill site dated 21.2.1980 (appendix 3) indicates that spot samples of the surface water and groundwater quality indicate that the ammoniacal nitrogen ranges from 0.09 mg/l to 0.6 mg/l prior to the development of the site and that the Iron concentrations in surface water between 0.6 and 10 mg/l which represents the natural concentrations for this environment (pre landfill development). It is likely to reflect the presence of peat deposits with concentrations in groundwater (2 – 40 mg/l) being recorded higher than those in surface water. The high concentrations of iron are likely to suggest the presence of colloidal iron within the natural environment.

Table 3: relevant baseline data (Aspinwall 1980) pre landfill development

	Ammoniacal Nitrogen (mg/l)	Fe (mg/l)	BOD (mgl)	pH
Mire Standing water	0.25	2.09	3.5	6.1
Bryn Posteg Stream	0.12	10.8	2	7.3
Bryn Posteg Spring	0.18	8.8	1	7.0
Bradnant Adit	0.2	1.17	3	6.8
Site Stream by road	0.16	7.6	2	6.9
Stream leaving the site	0.21	0.63	1.7	5.8
GROUNDWATER				
BH1	0.09	5.2	2	6.1
BH2	0.15	21.2	2	9.5
BH3	0.17	3.11	2.5	7.8
BH4	0.14	4.5	7	8.1
BH4A	0.42	10.1	7	7.6
BH5	0.01	4.1	3.5	7.2
BH5A	0.15	2.61	2	7.1
BH6	0.25	25.7	10.2	7.4
BH6A	0.22	3.59	10	8.3
BH7	0.32	2.56	4.5	7.4
BH7A	0.3	7.5	5	7.4
BH8	0.23	2.45	3	7.3
BH9	0.29	10.2	4	6.6
BH10	0.28	7.3	6	9.6
BH10A	0.6	40	14	9

3.1.7 The above table indicates that the environmental water quality standards for iron were exceeded prior to the development of the landfill site. Caution should be used as these represent spot samples and no further information is available on whether these represent dissolved or total iron concentrations.

4 SCREENING TESTS FRESH WATER

4.1 Test 1: Check whether the concentration of the pollutant is more than 10% of the EQS Limits.

4.1.1 This screening test assesses whether the concentrations of the discharged substances exceed 10 percent of the EQS, irrelevant to the quality and flow of the receiving body of water. Therefore it purely assesses the quality of the discharged effluent.

4.1.2 The current EQS standards have been sourced from the following two environment Agency spreadsheets:

- Fresh waters specific pollutants and operational environmental quality standards (EQS) accessed 12/3/2019
- Freshwaters priority hazardous substances, priority substances and other pollutants – accessed 12/3/2019

4.1.3 The H1 access database tool has been utilised to assess the pollution potential and is included in Appendix 4.

Table 4: Results of screening against 10%EQS

Substance	P1 compliance limit conc. (µg/l)	Annual Average EQS (µg/l)	MAC conc. (µg/l)	MAC EQS (µg/l)	Pass/Fail
Ammoniacal Nitrogen as N	250	300		300	Fail
Iron	5000	1000	-	-	Fail
BOD	20 mg/l	20 mg/l	-	-	Fail

4.1.4 The iron concentrations have been back calculated from acceptable concentrations in Test 3. The above table indicate that all parameters associated with the treatment of surface water and regulated by the emissions limits at P1 are above 10% of the EQS.

4.2 Test 2: Does the process contribution (PC) exceed 4 percent of the EQS

4.2.1 The discharge from the site comprises forms the base flow within the Nant y Bradnant at its headwaters and as such, there is no receiving water body at the site. Therefore, the quality of the discharge represents the quality of the Nant -y- Bradnant at this point. In order to assess the impacts on the downstream water quality, the assessment has been undertaken on a theoretical assessment point for the Nant y Bradnant where the combined flow (including the discharge) is 60L/s. This is both an arbitrary and theoretical assessment point and assumes that the Nant y Bradnant increases in size along its course to the confluence with the River Severn. There are no gauging stations present on the Nant y Bradnant.

4.2.2 In addition, the risks from the treated discharge from the site are also assessed at the point where the Nant y Bradnant enters into the River Severn. The nearest gauging station is located on the River Severn at Dolwen which is immediately down stream of the confluence with the Nant Y Bradnant.

4.2.3 Following the assessment methodology of Test 2 – Surface Water Discharges, for the H1 the process contributions released to the Nant y Bradnant and Severn were calculated as follow:

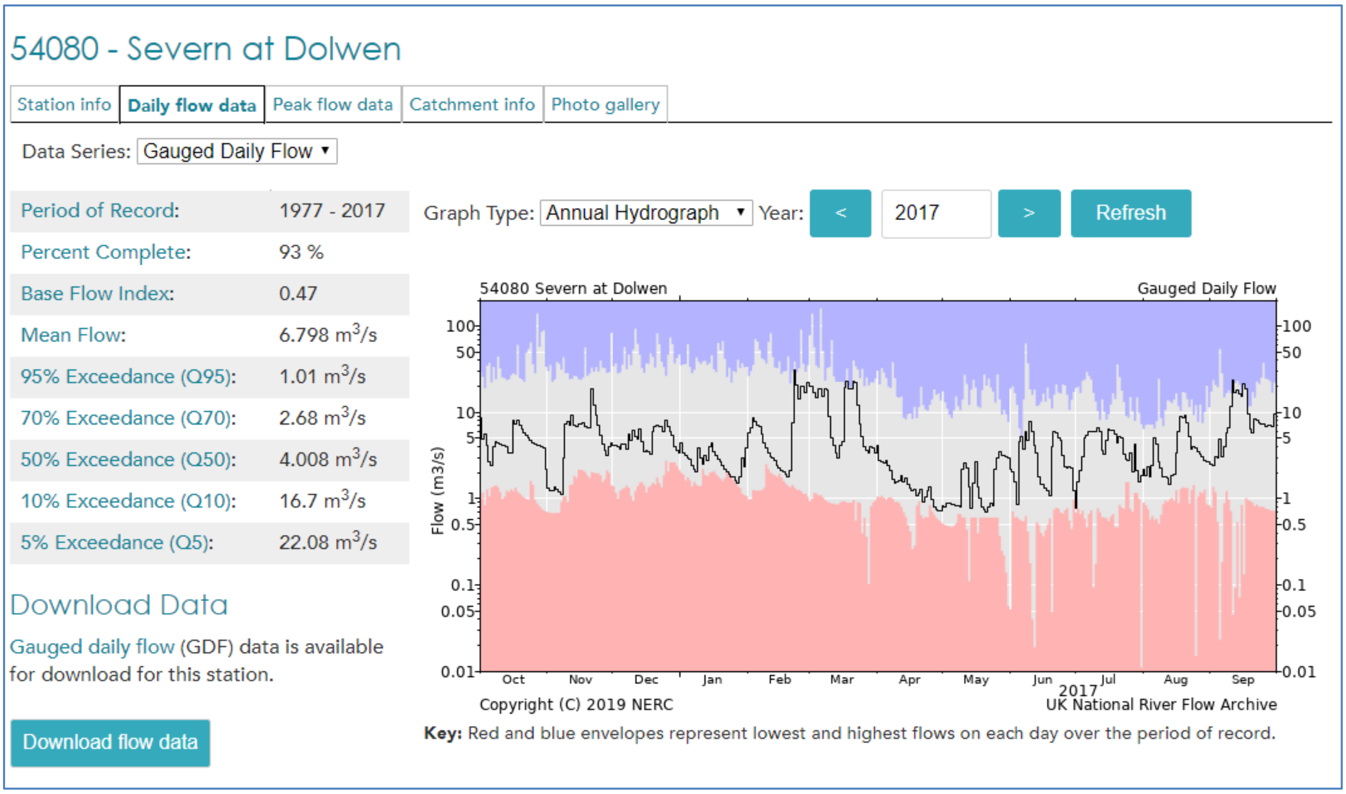
$$PC = \frac{(EFR * RCperm)}{(EFR + RFR)} \quad (1)$$

Where

PC = process contribution (μg/l)
EFR = effluent flow rate (m^3/s)
RC_{perm} = release concentration from RO treatment work
RFR= river flow rate (m^3/s)

4.2.4 As indicated above, the assessment on the Nant y Bradnant is based on a theoretical point with a discharge of 30L/s such that the combined flow is 60 L/s. This is an arbitrary flow based on double the discharge rate, i.e. equal proportions of discharge to accumulated flow with the Nant y Bradnant.

4.2.5 An extract from the Nation River Archives is presented below. This indicates that the Q95 flow within the R. Severn at Dolwen is 1.01 m^3/s. The maximum discharge from the site is 0.03m^3/s (30 L/S).



Data was sourced from http://nrfa.ceh.ac.uk/data/search.

Table 5a: Process contributions (Nant Y Bradnant)

Substance	MAC conc. (µg/l)	EFR (m^3/s)	RFR (m^3/s)	PC	4% EQS	
Ammoniacal Nitrogen as N	250	0.03	0.03	125	12	Fail
Iron	5000	0.03	0.03	2500	40	Fail
BOD	20	0.03	0.03	10	0.8	Fail

Table 5b: Process contributions (R. Severn)

Substance	MAC conc. (µg/l)	EFR (m^3/s)	RFR (m^3/s)	PC	4% EQS	
Ammoniacal Nitrogen as N	250	0.03	1.01	7.2	12	Pass
Iron	5000	0.03	1.01	144	40	Fail
BOD	20	0.03	1.01	0.6	0.8	Pass

4.3 Test 3: does the difference between upstream quality and the Predicted Environmental Concentration (PEC) exceed 10 percent of the EQS?

4.3.1 The PEC is the predicted concentration in the receiving water downstream of the discharge and is calculated using the following formula:

$$PEC = \frac{(EFR * RC_{perm}) + (RFR * BC)}{(EFR + RFR)}$$

Where

PEC = Predicted Environmental Concentration (µg/l)
BC = Background concentration (µg/l)
RC- Release concentration (ug/l)

4.3.2 As indicated above, the background concentrations are taken from an investigation that predate the development of the site and therefore is considered to represent baseline conditions. Please note that the results presented below are based on the calculation above which differs from the H1 tool which assumes that the PEC can be added to the BC. Due to the flow rates this has an impact on the results in the H1 model. The spreadsheet calculations are included in Appendix 4.

Table 6a: Predicted Environmental Concentrations (mg/l) Nant y Bradnant

	Units	RC	BC	PEC	PEC-BC	EQS	10%EQS
Ammoniacal Nitrogen	ug/l	250	200	225	25	300	30
Iron	ug/l	5000	5180	5090	-90*	1000	100
BOD	mg/l	20	2.2	11.1	8.9	20	2

***** The negative number is due to the discharge having a lower iron concentration than the background pre landfill data.

4.3.3 The above table indicates that there is no discernible deterioration in the concentrations above 10% with the exception of BOD. It is noted that whilst the predicted concentrations are below the EQS that the emission limit for BOD fails this 10% deterioration assessment. However when using site specific discharge data which indicates that the concentrations of BOD are rarely above 5 mg/l (95%ile value was 4 mg/l), the BOD passes this screening test.

4.3.4 This peculiarity arises due to the difference between the background concentrations and the emission limits set at the EQS.

Table 6b: Predicted Environmental Concentrations (mg/l) River Severn

	BC	RC	PEC	PEC-BC	10%EQS
NH4 (mg/l)	0.2	0.25	0.2	0.001	0.03
Fe (mg/l)	5.18	5	5.17	-0.005	0.1
BOD (mg/l)	2.2	20	2.7	0.5	2

Note: concentrations have been converted to mg/l for ease of interpretation

4.3.5 The surface water risk assessment indicates that the predict concentrations within the River Severn are extremely low and would not be discernible above background concentrations.

4.3.6 In conclusion, it is considered that the treatment system will meet the requirements of step 3 provided that the current emission limits within P1 are met. This includes for limited dilution within the Nant y Bradnant which is the initial receiving water body. It is noted that this stream arises from within the boundaries of the landfill and therefore the assessment is undertaken at a theoretical point downstream where the accumulated flow within the stream matches the discharge rate.

4.4 Part A Freshwater screening test 4: does the PEC exceed the EQS in the receiving water downstream of the discharge?

4.4.1 The final test of the part A of the Freshwater screening is to determine whether the PEC exceeds the EQS. The test is split into two sections, test 4A and 4B, with test 4A relating to the average concentration and test 4B relating to the max concentration.

Table 7a: STEP 4 is PEC > EQS Nant Y Bradnant

	Units	RC	BC	PEC	EQS
Ammoniacal Nitrogen	ug/l	250	200	225	300
Iron	ug/l	5000	5180	5090	1000
BOD	mg/l	20	2.2	11.1	20

4.4.2 Ammoniacal nitrogen at the current emission limit of 0.25 mg/l passes the test at the maximum concentrations as presented in Table 7 above. BOD concentrations also pass this test. The concentrations of iron fail this test due to the high background of iron in the receiving water body (based on background concentrations pre-development of the landfill site). This indicates that the natural (pre development) surface water quality was inferior to the current water quality standards.

4.4.3 The predicted concentrations in the River Severn. These indicate that as the concentrations are limited to the EQS or background data, there is no discernible effects on the water quality.

Table 7b: STEP 4 is PEC > EQS River Severn

	Units	RC	BC	PEC	EQS
Ammoniacal Nitrogen	ug/l	250	200	201	300
Iron	ug/l	5000	5180	5175	1000
BOD	mg/l	20	2.2	2.7	20

4.5 Water impact: Significant loads

There are no priority substances as defined within the guidance identified the discharge and therefore no assessment of significant loads is required. The discharge is of treated surface water from the site to remove the fine particles from suspension.

5 MODELLING

5.1.1 No modelling of the river needs has been undertaken to derive the appropriate ammoniacal nitrogen discharge criteria for the site. The assessment is based on a conservative assumption that the maximum discharge concentration of ammoniacal nitrogen occurs during the periods of lowest flow in the receiving water body. In practise, the discharge from the site is likely to be significantly less during these periods of low flow based on the assumption that this is a discharge of surface water runoff.

5.1.2 Therefore any additional modelling which would allow the correlation between flows and concentrations would result in a higher permissible discharge concentration.

6 SENSITIVITY OF RECEIVING ENVIRONMENT

6.1 Environmental Designations

6.1.1 There are no statutory designated sites immediately down stream of the discharge and the assessed water body comprising the River Severn. However it is recognised that the Nant y Bradnant was recorded as of good water quality during the first water directive assessment and therefore may be regarded as being a moderate sensitivity. Accordingly the risks to the Nant y Bradnant have been included within this assessment.

6.1.2 It is noted that the Nant Y Bradnant drains an area with a significant industrial lead mining heritage and local enrichment of metal species would be expected. This is confirmed by the historic data which indicates high concentrations of iron in excess of the current environmental water quality standards.

7 Monitoring Requirements

7.1 Review of existing requirement on eastern catchment.

7.1.1 The monitoring of the surface water discharge from the eastern catchment is regulated under the existing environmental permit via monitoring point P1. Ammoniacal nitrogen and BOD provide a general indication of the overall surface water quality.

7.1.2 The additional treatment using ferric chloride and Aquatreat 156 is discussed above. Aquatreat degrades to ammonia, carbon oxides and nitrogen oxides and therefore the monitoring of ammoniacal nitrogen as part of the discharge consent would remain appropriate to be protective of pollution from this additive.

7.1.3 During the establishment of the treatment technology, it would be advisable to monitor for **dissolved** iron concentrations in the discharge, however the treatment system is designed such that iron would precipitate out of solution and would not be expected to be present in the surface water discharge. A period of 12 months monitoring of iron is proposed in addition to the existing permitted monitoring regime to demonstrate the removal of iron from the discharge.

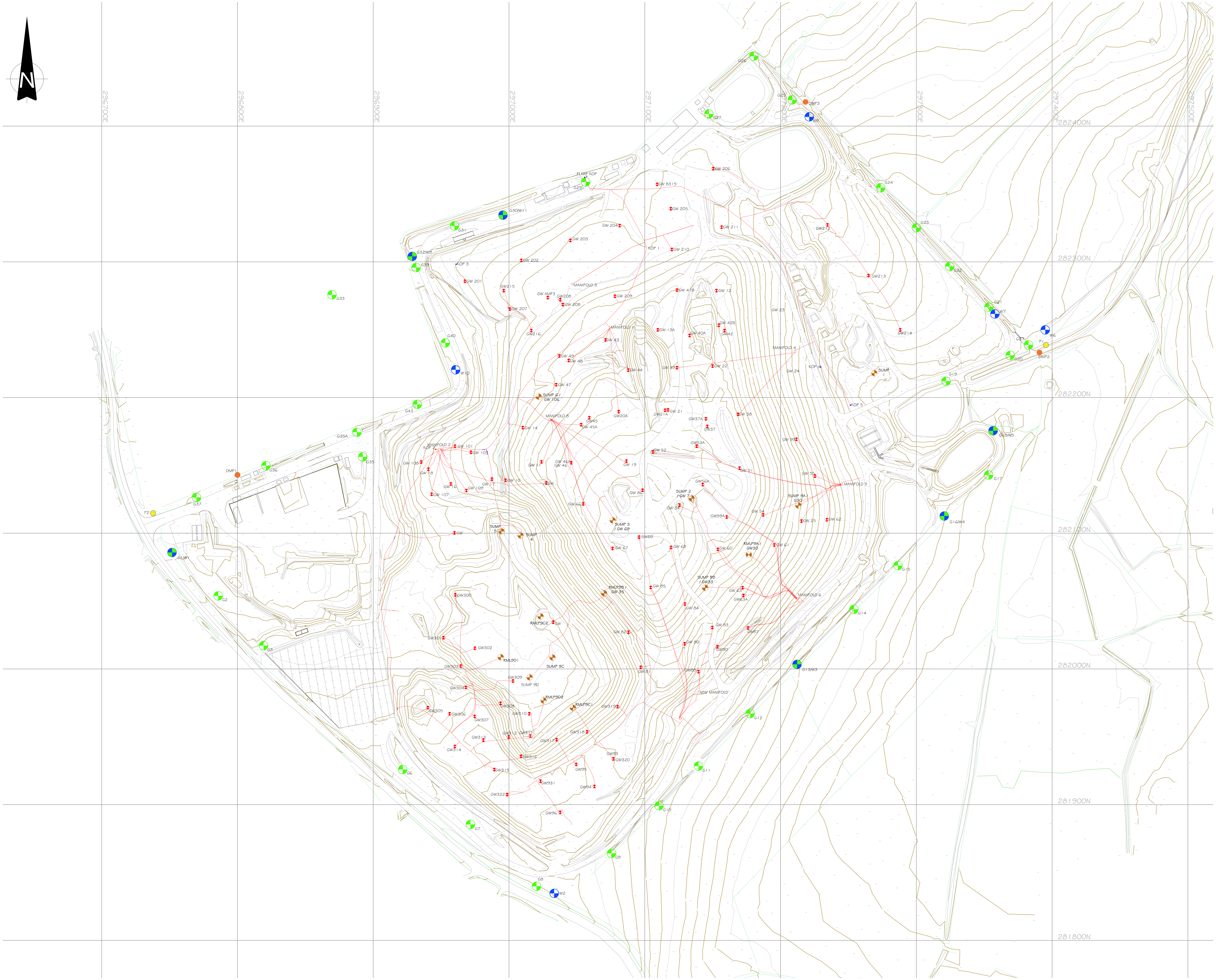
8 CONCLUSION AND DISCUSSION

8.1.1 This surface water risk assessment has reviewed the potential pollution risk of the proposed surface water treatment system associated with Lagoon 3 at Bryn Posteg Landfill Site together with the existing limits on the surface water discharge in accordance with the permit requirements. This review has shown that the baseline quality (pre development of the landfill site) is inferior to the current environmental water quality standards through the natural concentrations of iron in both groundwater and surface water samples obtained in 1980.

8.1.2 The assessment of the risk as indicated that the net contribution of iron from the treatment system is limited to less than 10% of the EQS with a control limit of 5 mg/l.

8.1.3 The current Ammoniacal nitrogen concentrations and BOD criteria are considered to remain appropriate.

DRAWINGS



NOTE

1. DO NOT SCALE FROM THIS DRAWING, WORK FROM FIGURED DIMENSIONS ONLY. ALL DIMENSIONS ARE IN MILLIMETRES AND ALL LEVELS ARE IN METRES ABOVE ORDNANCE DATUM U.N.O.

2. NO DEVIATION FROM THE DETAILS SHOWN ON THIS DRAWING WILL BE ALLOWED WITHOUT THE PRIOR PERMISSION IN WRITING.

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4. MAXIMUM SURCHARGE LOAD ON 50.0m FLOOR 20KN/m2 UNLESS OTHERWISE STATED.

LEGEND

- IN WASTE GAS WELL
- LEACHATE COLLECTION / MONITORING POINT
- PERIMETER GAS MONITORING BOREHOLE
- PERIMETER GROUNDWATER MONITORING BOREHOLE
- PERIMETER GAS & GROUNDWATER MONITORING BOREHOLE
- SURFACE WATER MONITORING LOCATION
- DUST MONITORING POINT

REV	MODIFICATIONS	BY	RE	AP	DATE
P3	MINOR AMENDMENTS	DA	SO	SO	31.05.18
P2	MINOR AMENDMENTS	DA	SO	SO	29.05.18
P1	ISSUED FOR COMMENT	RWG	SO	SO	04.05.18

POTTERS WASTE MANAGEMENT

PROJECT:

BRYN POSTEG LANDFILL SITE

TITLE:

GAS EXTRACTION AND MONITORING INFRASTRUCTURE PLAN

DRAWN BY	DATE	
RWG	04.05.2018	
REVIEWED BY	SCALE @ A1	JOB REF:
SO	1:1250	3376
AUTHORISED BY	ISSUE	REVISION
SO	S1	P3

DRAWING NUMBER

3376-CAU-XX-XX-DR-V-1801

Caulmert

engineering environmental planning

WWW.CAULMERT.COM

Registered Office: InTec, Parc Menai, Bangor, Gwynedd, LL57 4FG Company Registered No: 06716319

APPENDIX 1

Section 1: Identification of Substance/mixture and of the company undertaking

1.1: Product Identifier

Product Name AQUATREAT 156

1.2: Relevant Identified use of substance/mixture and uses advised against

1.3: Details of the Supplier of the safety data sheet

Company Name: Aquatreat

Albany House
North Dock
Llanelli
Carmarthenshire
SA15 2LF

Telephone: 01554 775236

Fax: 01554 772253

E-mail: enquiries@aquatreat.co.uk

Website: www.aquatreat.co.uk

1.4: Emergency Telephone Numbers:

Emergency Telephone: 0333 333 949

Section 2: Hazards Identification

2.1: Classification of substance/mixture according to Regulation (EC) No 1272/2008

Classification under CLP: NC Not Classified as Hazardous

Additional Information:

2.2: Label Elements: Labelling according to Regulation (EC) No 1272/2008 [CLP/GHS]

Label elements under CLP: NC Not Classified as Hazardous

Signal Words:

Hazard Pictograms:

Precautionary Statements

Wear protective gloves/protective clothing/eye protection/face protection.

Keep out of reach of children.

2.3: Other Hazards

Section 3: Composition information on hazardous ingredients

Does not contain any compnents classified as hazardous

EINECS	CAS No	CLP Classification	Percent

Section 4: First Aid Measures

4.1: Description of First Aid measures

Skin Contact: Remove contaminated clothing. Wash contaminated area well with soap and water. If irritation persists obtain medical attention.

Eye Contact: Irrigate eye with water for 15 minutes. If irritation or redness persists seek medical attention.

Ingestion: Do not induce vomiting. Do not give anything by mouth to an unconscious person. If conscious rinse out mouth with water and give water to drink. Rest and reassure patient and obtain medical attention

Inhalation: Remove person to fresh air. If recovery is delayed seek medical attention.

4.2: Most important symptoms and effects both accute and delayed

Skin Contact: No data available

Eye Contact: No data available

Ingestion: No data available

Inhalation: No data available

4.3: Indication of any immediate medical treatment and special treatment required

Section 5: Fire fighting measures

5.1: Extinguishing media

Foam, dry powder, CO2

Unsuitable Media

None

5.2: Special hazards arising from the substance/mixture

Product does not burn readily, but flammable dust clouds may be formed in air.

5.3: Advice for firefighters

Chemical protection suit, gloves, goggles, self-contained breathing apparatus.

Section 6: Accidental Release Measures

6.1: Personal precautions, protective equipment and emergency procedures

For personal protection see section 8.

6.2: Environmental precautions

Should not be released into the environment.

6.3: Methods and Materials for containment and clean up

Do not flush into surface waters or sanitary sewer system. Sweep up and shovel into suitable containers for disposal. Residues and small spillages may be hosed away with water. Spilled product which becomes wet may cause a slip hazard.

6.4: References to other sections

Section 7.0: Handling and Storage

7.1: Precautions for safe handling

Avoid dust formation during handling. For personal protection see section 8.

7.2: Conditions for safe storage.

To avoid product degradation and equipment corrosion, do not use iron, copper or aluminium containers or equipment. The product is hygroscopic. Protect from moisture.

7.4: Specific End Use(s)

Section 8: Exposurecontrols/PersonalProtection

8.1: Control Parameters

Contains no substances with occupational exposure limit values.

WORKPLACE EXPOSURE		Respirable Dust	
8 Hour TWA	15MinSTEL	8 HoursTWA	15MinSTEL

8.2: Exposure Controls

Engineering Measures: Handle in accordance with good industrial hygiene and safety practice. Ensure adequate ventilation. Ensure that eyewash stations and safety showers are close to the workstation location.

Respiratory Protection: In case of inadequate ventilation wear respiratory protection. (filter P2)

Hand Protection: Nitrile rubber gloves

Eye Protection: Safety glasses/gogles

Skin Protection: Normal work overalls

Section 9.0: Physical and ChemicalProperties

9.1: Information on basic physical and chemical properties

State: Solid

Colour: White

Odour: Odourless

Relative Density: n/a

pH: n/a

9.2: Other Information

Section 10: Stability and Reactivity

10.1: Reactivity

10.2: Chemical Stability

Stable at ambient temperature.

10.3: Possibility of Hazardous Reactions

None known

10.4: Conditions to Avoid

Wet, damp, and humid conditions

10.5: Incompatible Materials

Strong oxidizing agents

10.6: Hazardous Decomposition Products

ammonia, Carbon oxides (COx), Nitrogen oxides (NOx)

Section 11: Toxicological Information

AQUATREAT 156

ORAL	RAT	LD50	>2500 mg/kg

Section 12: Ecological Information

12.1: Toxicity

96 Hr LC50 (fish) expected to be > 100ppm by analogy to similar products

12.2: Persistence and Biodegradable

Ready biodegradability/OECD Test Guideline 301 D/28 d: < 10 %

12.3: Bioaccumulative Potential

Bioaccumulation is unlikely. Because of the high molecular weight of the polymer diffusion through biological membranes is very small.

12.4: Mobility in Soil

12.5: Results of PBT and vPvB Assessment

This substance/mixture contains no components considered to be either persistent, bioaccumulative and
toxic (PBT), or very persistent and very bioaccumulative (vPvB) at levels of 0.1% or higher.

12.6: Other adverse effects

Section 13: Disposal Information

Recycling, recovery and reuse of materials is recommended if permitted by regulations.The organic ingredients can be incinerated in a suitable installation when in accordance with local regulations.Packages must be disposed of according to local and national regulations.

Section 14: Transport Information

UN Number	
Shipping Name	Not classified as dangerous for transport
Transport Class	
Packing Group	
Environment Hazard	
Special Precautions	

Transport in bulk according to Annex II of MARPOL73/78 and the IBC Code

Section 15: Regulatory Information

15.1: Safety, Health and Environmental regulations/legislation specific for the substance/mixture

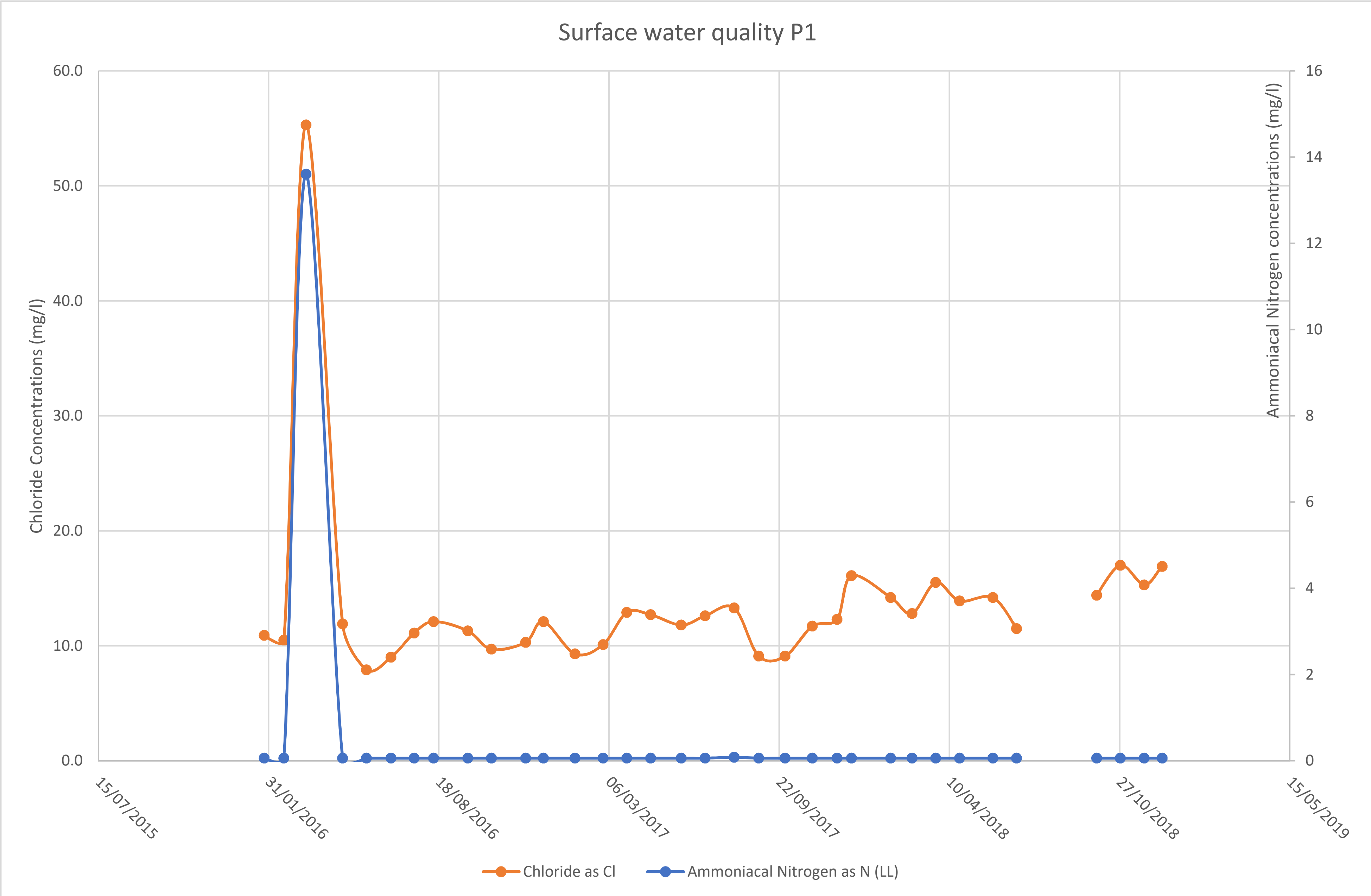
15.2: Chemical safety assessment

Section 16: Other information

The above information is based on our present knowledge of the product at the time of publication. It is given in good faith, no warranty is implied as to the quality or specification of the product. Information contained in this data does not constitute an assessment of workplace risks. The user must satisfy himself that the product is entirely suitable for their purpose

APPENDIX 2

compliance Level		6 - 9	N/A	0.25	N/A	50	20	N/A	N/A	N/A	N/A	N/A	N/A
LOCATION	DATE	pH	Conductivity-Electrical 20C	Ammoniacal Nitrogen as N (LL)	Chloride as Cl	Total Suspended Solids	BOD + ATU (5 day)	EH >C6 - C40	EH >C6 - C8	EH >C8 - C10	EH >C16 - C24	EH >C24 - C40	EH >C10 - C16
		pH units	µS/cm	mg/l	mg/l	mg/l	mg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l
SW 1	26/01/2016	6.9	95	0.06	10.9	11	1	<10	<10	<10	<10	<10	<10
SW 1	18/02/2016	7.4	99	0.06	10.5	20	1	<10	<10	<10	<10	<10	<10
SW 1	15/03/2016	6.7	459	13.6	55.3	30	10	<10	<10	<10	<10	<10	<10
SW 1	27/04/2016	7.4	103	0.06	11.9	1	1	12	<10	<10	<10	12	<10
SW 1	25/05/2016	7.2	97	0.06	7.9	2	2	<10	<10	<10	<10	<10	<10
SW 1	23/06/2016	7.5	101	0.06	9.0	1	1	25	<10	<10	<10	25	<10
SW 1	20/07/2016	7.3	106	0.06	11.1	3	2	36	<10	<10	<10	36	<10
SW 1	12/08/2016	7.8	111	0.06	12.1	5	4	<10	<10	<10	<10	<10	<10
SW 1	21/09/2016	7.0	105	0.06	11.3	5	1	<40	<40	<40	<40	<40	<40
SW 1	19/10/2016	6.5	105	0.06	9.7	11	2	<10	<10	<10	<10	<10	<10
SW 1	28/11/2016	6.9	113	0.06	10.3	2	1	<10	<10	<10	<10	<10	<10
SW 1	19/12/2016	6.9	110	0.06	12.1	3	1	<100	<100	<100	<100	<100	<100
SW 1	25/01/2017	6.6	110	0.06	9.3	4	1	21	10	10	10	21	10
SW 1	27/02/2017	6.6	108	0.06	10.1	6	1	10	10	10	10	10	10
SW 1	27/03/2017	6.6	111	0.06	12.9	25	1	10	10	10	10	10	10
SW 1	24/04/2017	6.9	117	0.06	12.7	4	3	27	10	10	10	27	10
SW 1	30/05/2017	7.1	113	0.06	11.8	38	5	10	10	10	10	10	10
SW 1	27/06/2017	7.2	112	0.06	12.6	8	2	10	10	10	10	10	10
SW 1	31/07/2017	6.8	113	0.08	13.3	30	1	40	10	40	40	40	40
SW 1	29/08/2017	6.8	111	0.06	9.1	2	1	20	10	20	20	20	20
SW 1	29/09/2017	6.8	111	0.06	9.1	2	3	10	10	10	10	10	10
SW 1	31/10/2017	6.5	117	0.06	11.7	2	2	40	40	40	40	40	40
SW 1	29/11/2017	6.3	126	0.06	12.3	1	1	10	10	10	10	10	10
SW 1	16/12/2017	6.4	134	0.06	16.1	5	1	10	10	10	10	10	10
P1 (SW 1)	31/01/2018	7.1	109	0.06	14.2	2	1	10	10	10	10	10	10
P1 (SW 1)	25/02/2018	6.9	132	0.06	12.8	6	1	10	10	10	10	10	10
P1 (SW 1)	25/03/2018	7	117	0.06	15.5	2	1	10	10	10	10	10	10
P1 (SW 1)	22/04/2018	6.6	129	0.06	13.9	10	2	10	10	10	10	10	10
P1 (SW 1)	31/05/2018	6.9	117	0.06	14.2	13	1	10	10	10	10	10	10
P1 (SW 1)	28/06/2018	7.6	111	0.06	11.5	9	4	10	10	10	10	10	10
P1 (SW 1)	02/08/2018												
P1 (SW 1)	23/08/2018												
P1 (SW 1)	30/09/2018	6.7	249	0.06	14.4	4	1	20	20	20	20	20	20
P1 (SW 1)	28/10/2018	6.4	123	0.06	17	2	1	13	10	10	10	13	10
P1 (SW 1)	25/11/2018	6.4	124	0.06	15.3	2	1	46	10	10	10	46	10
P1 (SW 1)	16/12/2018	6.2	126	0.06	16.9	8	1	40	40	40	40	40	40
min		6.2	95.4	0.1	7.9	1.0	1.0	10.0	10.0	10.0	10.0	10.0	10.0
Average		6.9	127.2	0.1	12.2	8.2	1.6	18.8	13.2	15.0	15.0	18.8	15.0
95%ile		7.5	174.2	0.1	16.4	30.0	4.0	40.0	39.0	40.0	40.0	40.0	40.0
max		7.8	459.0	13.6	55.3	38.0	10.0	46.0	40.0	40.0	40.0	46.0	40.0
count		34	34	34	34	34	34	25	22	22	22	25	22



Surface water quality P1
Chloride Concentrations (mg/l)
Ammoniacal Nitrogen concentrations (mg/l)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
16
14
12
10
8
6
4
2
0
15/07/2015
31/01/2016
18/08/2016
06/03/2017
22/09/2017
10/04/2018
27/10/2018
15/05/2019
Chloride as Cl
Ammoniacal Nitrogen as N (LL)

APPENDIX 3

THE HYDROGEOLOGICAL INVESTIGATION AND LANDFILL DESIGN OF AN UPLAND LANDFILL IN POWYS

R Aspinwall BSc.,CEng.,MInstWM.,MIMM.,MIWES.,MIGeol.,FGS.
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THE HYDROGEOLOGICAL INVESTIGATION AND LANDFILL DESIGN OF AN UPLAND LANDFILL IN POWYS

R Aspinwall BSc.,CEng.,MInstWM., MIMM., MIWES., MIGeol., FGS.
J N Davies BSc.,CEng.,MICE., MIWES., MIPHE.

1. BACKGROUND

1.1 This paper summarises work executed to a brief prepared by Montgomery District Council, to locate and develop a new landfill facility which would meet the Council's statutory responsibility to dispose of waste in an environmentally acceptable manner. The District Council's Chief Environmental Health Officer, Mr Tecwyn Roberts, explains the Council's position in his paper, which should be read in conjunction with this.

1.2 Figure 1 sets out the sequence of steps which were taken to identify and secure the facility in this case. Figure 2 shows our standard "blueprint" approach, whilst Figure 3 identifies the licencing and planning decision routes in full. The consultants' brief commenced with an analysis of some twenty-two potential sites identified by the Environmental Health Department. Major constraints on landfill development in the District Council's area were seen to be:

i) Much of the area is within the catchment of the River Severn, a major regulated surface water resource and fishery.

ii) Other rivers have high amenity and recreational values as well as local water resource values.

iii) The area is one of high landscape value.

iv) Upland areas are characterised by relatively steep slopes and thin cover material, giving difficult conditions for controlled landfill.

v) Lowland areas have adequate cover material but are heavily and profitably farmed.

1.3 The District Survey essentially comprised an appraisal of the merits and demerits of each site for development as an engineered landfill, and included aspects of the geology, hydrogeology, hydrology, and meteorology to determine the likely generation and fate of leachate in each case. An essential part of the analysis was however to attempt to find a self-sufficiency of earth materials of a kind which would permit a high degree of environmental control over the basic design, operation and restoration of the site. Of all the options considered only Bryn Posteg revealed, at this early stage, considerable potential.

1.4 Having identified Bryn Posteg the next stage was to carry out a Reconnaissance Survey of the site, the first stage shown on Figure 2. Such a survey is essentially a relatively low cost appraisal of the site, but aims to identify those major constraints at a particular site which would render the project non-viable, and those which would require significant engineering works to overcome. Systematic records are also made of all matters considered to be relevant to the proposal, and generally fall under the headings shown on Figure 2.

At Bryn Posteg, the reconnaissance survey was fortified by the construction of 16 trial pits on site, and the use of either this technique and/or rotary augering is, in our experience, very often a worthwhile addition to the data bank at moderate cost.

1.5 The Reconnaissance Survey did not reveal any insuperable constraints, given that the District Council were only prepared to operate a modern ethical landfill, and therefore instructions were received to carry out a full site investigation which comprised twelve boreholes with suitable instrumentation and twenty-seven trial pits. The scope of the full site investigation covered most of the topics shown on Figure 3, but in addition included investigation of the relevance of a disused lead mine which underlies much of the site.

1.6 The full site investigation enabled a costed draft landfill design to be advanced to the District Council for its approval, which was granted, so that full landfill design could proceed.

This paper summarises some of the major features of this project, which follows a logic found to be productive for both public and private sector clients in the Waste Management field.

2. HYDROGEOLOGY OF THE SITE AREA

2.1 Basic Geology

2.1.1 General

The geology of the site can be divided into the solid geology of the older rocks occuring in the area and the superficial geology of more recent deposits which have been emplaced by the processes of weathering, glaciation and organic activity.

In general terms the site consists of a downward succession of Recent clays and weathered shales overlying solid shales of the Upper Llandovery Series of the Silurian era. In the topographically lowest part of the area there is however a deposit of peat which in turn overlies clays and shale. A diagramatic section through the site is shown on Figure 4.

2.1.2 Peat

The Peat deposit is a post glacial formation of organic material. There are a number of classification methods for peat and mire types, although a mire is a continuously developing formation which can be at one of many stages. It is thought that the development of a mire occupies five main stages.

a) In a basin of standing or slowly flowing surface water organic material collects to form either a slow growing heavy peat over which water flows or a light peat which forms a vegetation mat on the water.

b) The accrual of peat tends to canalise the main flow of water.

c) Continued peat growth diverts the inflow from the basin, so that the water supply to the mire is restricted to precipitation.

d) Further accrual of peat leaves large areas of mire surface unaffected directly by flowing water, but subject to inundation when the water level within the peat rises during period of rainfall.

e) The continued peat growth causes the mire surface to rise above the effect of vertical oscillations of the flowing water. This dome is known as a cupola and possesses its own water table directly fed by precipitation.

The research carried out at this site during the reconnaissance survey revealed an early map of the area (1607) which showed a small lake in the position of the current peat area known as Llynbarre, although the depth of the lake was unknown. Boreholes drilled in the centre of the deposit showed the peat to be around 7.5 m thick underlain by soft silty clays which represent lake sediments. Trialpits on the edge of the deposit indicated a peat thickness of between 0.6 m to 4.0 m. These results indicate an infilled depression with the thickest peat in its centre.

The peat at Bryn Posteg was typically dark brown and very soft with some large remains of birch timber. The peat exposed in trial pits along the northern end of the deposit was firmer and more cohesive.

We formed the view that the peat deposit was formed in a depression, the overall topography of which caused surface water to be trapped into a relatively stagnant lake in which the development of a mire has commenced. The mire is still in the process of development and is considered to be at a stage between b and c of the five stages listed.

2.1.3 Lake Sediments

The site investigation proved grey silty clay at least 2.5 metres deep becoming firmer with depth below the peat. This clay is considered to be lacustrine in nature and will have formed as a basal deposit in the original lake.

2.1.4 Weathered Shales and Clay

In all boreholes over the site a thickness of firm grey clay with pebbles and fragments of shale was found to vary between 1.2 and 13.5 m in thickness. The nature of the clay was variable from very firm dry weathered shale, weathered shales containing thin bands of broken shales with some clay binding, and green grey silty horizons containing rounded shale pebbles. It is considered that this clay is the product of two mechanisms, firstly the weathering of solid shales by continual freeze thaw action until the practical size of the rock is clay sized, but with larger fragments of the parent rock which were more resistant to this weathering attack; secondly, the removal and placement of weathered shales and broken shales by the action of glaciers and/or water. This secondary type of deposit will undergo a further alteration by the breakdown of the larger rock fragments by subsequent weathering and chemical alteration.

2.1.5 Unweathered rocks

The details on the geology in the immediate area were found to be scarce, with little work being done since publication of the old series one inch maps. These show no detail, but indicate that the rocks are of the Lower Silurian era. The rocks belong to the Upper Llandovery Series, which are generally blue, black and grey, very fine grained graptolitic shales and mudstones. The shale proved in the site investigation boreholes was typically very hard and no significant water entries were encountered. These rocks are normally highly cleaved and fissured, especially for the first few metres, and could therefore provide a conduit for groundwater flow. Our view was that whilst no water bearing fissures were encountered during the drilling it is reasonable to expect their presence beneath the site, and in working up the landfill design we considered it prudent to leave in-situ a layer of clay above the shales to prevent either leachate migration or the entry of groundwater from this formation.

2.1.6 Mining

There were obvious manifestations of mining at Bryn Posteg, with dereliction in the form of spoil heaps and the remains of three shafts and buildings. At the reconnaissance and site investigation stages old mine records and plans were obtained and scrutinised, so that the investigation could consider to what extent the mining might place a constraint on the landfill development.

2.1.7 Surface Water Hydrology

An attractive feature of the site, identified at an early stage, is that its surface water catchment is only some 28 hectares, and lies principally to the north on sloping land whose average gradient is 1 in 13. Rain falling on this area flows across the surface and through the sub soil into the peat area. There are also field drains installed in part of this catchment which discharged into the site area. An artificial drain, probably constructed during the active mining period, drained the peat area towards the east, but minimum gradient was 1 in 800, it was heavily vegetated and drainage of the mire was not effective.

Consideration of the geology and topography of the catchment would lead to the view that runoff from the catchment should be 'flashy'; however, because of the nature of the peat and its inefficient drainage, the mire tended to attenuate flows leaving the site within the drain. During the summer months, the drain ceased to flow, commencing again in November, when a small flow was evident in response to a period of heavy rainfall and an increase in mire water levels.

As no flow records existed for this drain, the catchment was modelled to determine the approximate expected low flow discharges. The modelling was based on the Institute of Hydrology low flow study (1978) and by this method the average daily flow is calculated from average meteorological data for the area. This flow is then broken down by statistical and empirical methods based on known data from other similar catchments. The result of the model is to produce a flow duration curve which gives the chance of a particular flow being exceeded for a given period. This model predicted that there is a 95% chance of the flow in the drain exceeding 2 m^3/hour on any one day of the year. This is clearly not the case as no flows were observed during the summer months. This deviation from the model is caused because average annual volumes for rainfall and evaporation are used by the model and these will not actually apply throughout the year since most of the annual evaporation takes place during the summer. However, a more significant factor in this case is the storage effect of the poorly drained mire. The combination of these effects is that the model's prediction of summer flows out of the catchment will be too high and winter flows too low.

Another approach was also taken which considered meteorological data which showed that during summer the actual average evapotranspiration is only just less than the actual rainfall, and therefore in the absence of any significant base flow contribution from an aquifer, the nett average effect is that theoretically there would be little or no flow from the catchment and the maximum average summer flow is calculated to be 18.5 m^3/day. However, during the winter months when there is minimal evapotranspiration a large percentage of the rainfall will cause runoff. The average flow from the catchment under these conditions has been calculated at around 110 m^3/day. Consideration of the geological, meteorological and hydrological data led us to the view that during the summer the existing mire accepts the low flow of 18.5 m^3/day from the catchment, holding the water in storage due to the poor drainage. This water is then available for evaporation.

It was calculated there is a potential evaporation of up to 75 m^3/day from the mire area during the summer period, and this excess potential evaporation explains the lowering of water levels within the mire below the drain invert and the consequential cessation of stream flow during the summer. In the Autumn and Winter however, rainfall greatly exceeds evaporation and runoff to the mire increases with a consequential increase in mire water levels which increase until they overflow down the drain.

Approximately 50 m downstream of the site boundary the drain has a confluence with a larger stream draining a catchment to the south of the site area. This catchment is steeper and has a measured area of around 64 hectares. There is a similar peat area in the lowest section of the catchment which is drained by the stream mentioned and there is a perennial flow in this stream which was observed at all times. It has been calculated that during the summer months the maximum expected average flow just upstream of the confluence with the site drain will be around 85 m^3/day and 2500 m^3/day during the winter. This order of flow agrees with our observation estimates.

Evaluation of the surface water hydrology gave firm indications that an important part of the landfill design, at Bryn Posteg, would be an efficient designed surface runoff diversion ditch around the perimeter of the consented area discharging into the stream. Summer storage of this water would not then take place over the mire area, thereby reducing evaporation losses so that the net flow in the stream leaving the site during the summer period might be expected to be slightly increased from the existing flow.

2.1.8 Groundwater Hydrology

Aquifers which can be defined as bodies of rock or sediment that are capable of storing, transmitting and yielding water are important natural resources and have to be protected from potential sources of pollution. The investigations at Bryn Posteg have demonstrated that no such body of rock or sediment is present. The weathered shales and clays can in general be described as aquicludes, that is they are essentially impervious but contain water which cannot be transmitted in significant quantities. However, they do contain thin bands of broken shale which will have minor fissure permeability and can therefore transmit groundwater in a localised fashion, which could provide leakage paths for leachate. The peat is an aquitard which will transmit water very slowly.

The groundwater hydrology of the site area has been studied and evaluated by surface evaluation, by observations made by hydrogeologists during the drilling of the boreholes and from information gained by the monitoring of piezometers installed in the boreholes.

Dealing firstly with the deeper boreholes which were sunk to observe the underlying shales, it was observed that there were no seepages of groundwater into any of the boreholes whilst drilling through the solid shales. In fact, water had to be added to the boreholes to remove the drilling cuttings. Following the installation of piezometers water levels rose only very slowly, indicating that the shales have a very low permeability and that no significant fissure flow was intercepted.

During drilling, the weathered shales and clays above the solid shales were found to be generally dry in all boreholes except when seepages were encountered in the bands of gravelly broken shales. Again, in all cases water had to be added as a drilling fluid so that drilling cuttings could be recovered.

It was observed that the bands of broken shale occurred predominantly at the lowest part of the site. Piezometers installed in the weathered shales elsewhere either remained dry for several days, or showed a very slow rise in water levels, indicating very low permeabilities. Observations of groundwater levels extended over a significantly long period from Autumn through to the winter period.

As a laboratory back-up on permeability data, undisturbed samples were taken for permeability determination and these gave results ranging between 1×10^{-3} and 3×10^{-7} cm/sec. for a loosely clay bound broken shale and a firm clay with shale fragments respectively.

Peat has a complex hydrogeology being highly compressible. It is known to compact if water content is reduced. Methods of evaluating the permeability of a deposit generally rely on Darcy's Law, which implies that the flow of water through a saturated medium is proportional to the hydraulic potential gradient, the constant of proportionality being the coefficient of permeability. In the case of peat, the coefficient of permeability is found to vary disproportionately to the hydraulic gradient. Experience in similar deposits elsewhere has shown the permeability to vary between 10^{-5} and 10^{-7} cm/sec. Another hydrogeologically significant feature of peat is that it has a very low storage coefficient which when coupled with the low permeability results in a rapid rise in groundwater levels in response to precipitation. This quickly reaches a point where further infiltration is not possible and water will run-off or pond on the surface depending on the topography. All of these features were observed at Bryn Posteg and were considered to be relevant to the drainage works identified as being necessary on the peat prior to and during the landfilling operation.

2.1.9 Water Quality

An important part of any hydrogeological appraisal is to carry out an analysis of existing surface and groundwaters. Water samples were taken from all boreholes and significant surrounding surface waters and springs. The purpose of this was twofold; firstly to provide a datum point of background water quality for comparison with future samples during the landfill operation, and secondly as part of the overall investigation, since the quality of a water will yield some information on the medium through which it has travelled. Selected water quality analyses are included in Appendix A, which also shows the location of the sampling points in and around the site. All of the analyses of groundwater from the boreholes show that the waters are typical of groundwater from shales. The waters are typically sodium bicarbonate in character but vary significantly in the degree of mineralisation, possibly reflecting variations in the residence time of infiltrating rainfall in the shales.

Sulphate is present in all samples in significant quantities. This sulphate together with small quantities of iron, manganese, zinc, copper, and nickel may be derived from oxidation of small quantities of disseminated pyrite in the shales. The alternative, oxidation of sulphide bearing mineral veins, is unlikely because the sulphate values are not particularly high and the only low pH values reflect a low residence time of the rainfall in the shales rather than acid mine drainage.

Albuminoid nitrogen and ammoniacal nitrogen are present in all samples at significant concentrations but generally below 1 mg/l, indicating that nitrogenous organic matter is present, probably derived from infiltration through the fairly acid soils of this area.

Some significant values of COD and BOD were found in groundwaters, all associated with higher phosphate concentrations and reflect movement of animal excreta through the soil profile into the shallow groundwater system.

All of the surface waters reflect the high antecedent rainfall and the streams in particular have characteristics of relatively unaltered rainfall. The low natural pH of the stream leaving the site reflects both rainfall and the peat in the catchment.

The waters have typically moderate concentrations of Albuminoid Nitrogen and ammoniacal nitrogen but less than 1 mg/l and very low phosphate. There was therefore no indication of contamination except by natural organic materials from vegetation.

Various springs and a mining adit were sampled as part of the survey. These waters are slightly more mineralised than the surface waters reflecting passage through soil and rock profiles. In particular manganese iron and nickel are higher and phosphate is detectable. However, sulphate and alkalinity are both low and the waters are considerably less mineralised than the groundwaters analysed from the boreholes. They are also of a calcium carbonate rather than sodium carbonate type and therefore reflect a lower residence time in the shales than the groundwaters. Since the waters taken from the boreholes are relatively highly mineralised and indicate long residence times, they are quite different from the waters occuring in the springs and streams which are more typical of a more rapid groundwater flow path. This evidence added to our conclusions, arrived at by other technical arguments that the shallow groundwaters under the site are not able to drain away from the site through the shales but form a relatively immobile situation isolated by the various clay horizons already described.

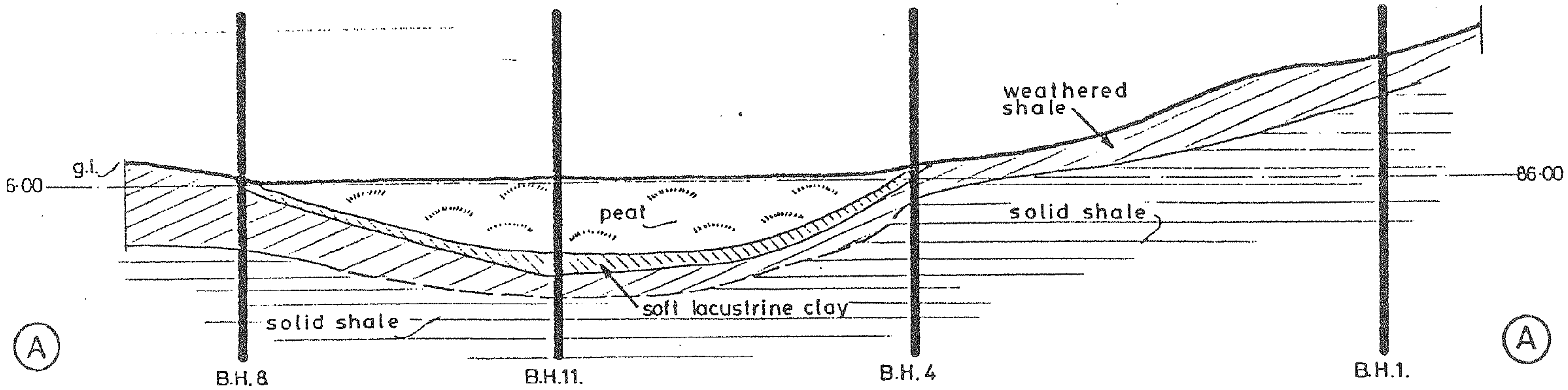
It was found that the quantities of lead are below the limits of detection in waters emerging from Bryn Posteg Spring and Bradnant Adit, and this together with the low sulphate concentrations indicate that these waters are not at all typical of mine drainage, but represent natural spring water.

2.1.10 Hydrogeological conclusions

1) Groundwater makes a contribution at relatively shallow levels (<5 m) to the prospective landfill area and must be diverted to avoid continuous formation of leachate.
2) Surface water contribution to leachate would be considerable and designed surface water cut-off system would be required.
3) No evidence for a direct hydraulic connection between shallow groundwaters and the lead mine workings or the reported drainage from the adits to the mine. However, all mine shafts and associated works would need to be rendered secure, both physically and hydraulically.
4) Water quality analyses establish a low but detectable level of 'natural' pollution in surface and groundwaters.

5) The natural clays present at the site were found to be suitable for use in a modern engineered landfill, developed in a phased manner, and covered by a low permeability cap to reduce infiltration and therefore leachate generation.

6) The natural peat could, after some drainage, be usefully incorporated in the final agricultural restoration of the site, thereby upgrading land standards, enhancing evapotranspiration and again reducing infiltration.



(REDUCTION – N.T.S.)

notes

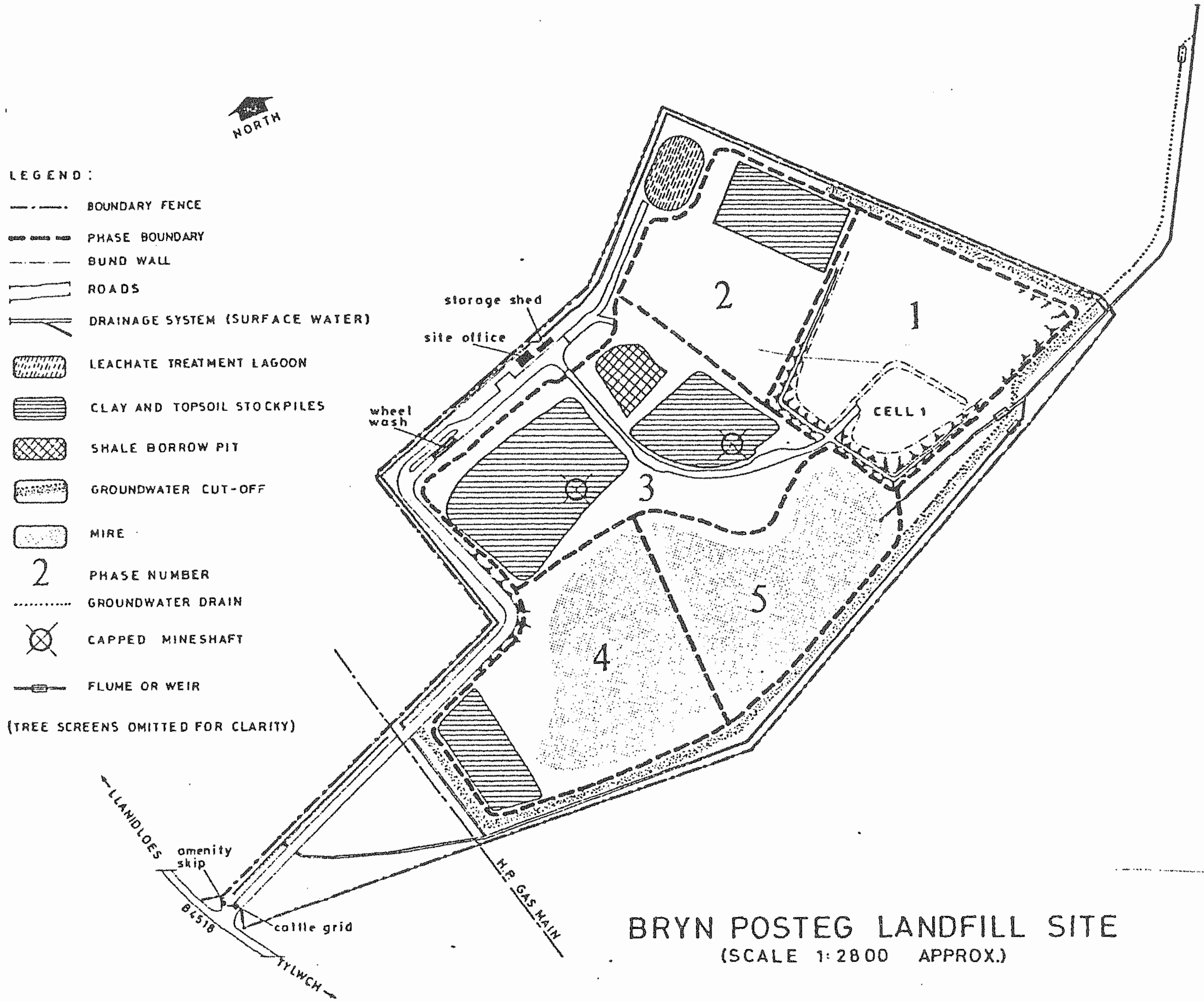
client
MONTGOMERY DISTRICT COUNCIL

job
BRYN POSTEG.

drawing
SKETCH GEOLOGICAL SECTION A·A.

number FIG. 1.	scale HORIZ. 1:1000 VERT. 1:500
drawn P·S·W.	checked K.B.
date JANUARY 1980	

Aspinwall
Hydrogeologists · Hydrologists · Water Engineers
PENGWERN COURT · HIGH
SHREWSBURY · SALOP ·



BRYN POSTEG LANDFILL SITE
(SCALE 1:2800 APPROX.)

(REDUCTION—N.T.S.)

APPENDIX A

Water Quality Analyses

	BH1	BH2	BH3	BH4	BH4A	BH5	BH5A	BH6	BH6A	BH7
pH	6.1	9.5	7.8	8.1	7.6	7.2	7.1	7.4	8.3	7.4
Electrical Conductivity (micro mhos)	87	705	510	1100	800	345	130	250	1070	330
Chloride	13	25	13	27	20	12	13	18	25	19
Hardness Total	19	20	60	74	216	42	38	52	68	80
Carbonate	3	20	60	74	216	42	30	52	68	80
Non Carbonate	16	0	0	0	0	0	8	0	0	0
Alkalinity	3	300	190	450	355	107	30	69	470	104
Dissolved Solids	55	520	355	755	570	245	97	200	770	220
Nitrate	2	4	LT 0.1	0.4	LT 0.1	3.2	3.2	5.2	1.1	LT 0.1
Ammoniacal Nitrogen	0.09	0.15	0.17	0.14	0.42	0.01	0.15	0.25	0.22	0.32
Albuminoid Nitrogen	0.19	0.27	0.17	0.33	1.14	0.17	0.35	1.28	0.24	0.08
Ca	4	7	18	20	60	12	12	13	20	24
Mg	3	1	4	6	16	3	2	5	4	5
Na	8	187	106	259	128	69	15	45	267	44
K	2	8	3	7	6	3	2	4	4	4
CO_3	2	180	114	270	213	64	18	41	282	62
SO_4	17	83	82	150	115	58	14	40	138	48
Cl	13	25	13	27	20	12	13	18	25	19
NO_3	9	18	0	2	0	14	14	23	5	0
Si	5	7	10	9	10	8	6	10	7	10
Fe	5.2	21.2	3.11	4.5	10.1	4.1	2.61	25.7	3.59	2.56
Zn	0.28	0.25	0.15	0.14	0.79	2.02	1	0.22	0.08	0.44
Cu	0.12	0.11	0.08	0.06	0.08	0.08	0.04	0.11	0.05	0.05
Pb	LT 0.03	0.03	LT 0.03	LT 0.03	LT 0.03	LT 0.03	LT 0.03	0.07	LT 0.03	LT 0.03
Mn	0.2	0.32	0.66	0.39	2.61	0.08	0.08	1.85	1.18	4
Cd	0.003	0.005	0.006	0.005	0.006	0.006	0.004	LT 0.001	0.006	LT 0.001
B	0.51	0.73	0.22	0.21	0.25	0.10	0.17	0.22	0.21	0.11
Ni	0.06	0.09	LT 0.03	0.04	0.07	0.03	LT 0.03	0.13	0.05	LT 0.03
Cr	LT 0.03	LT 0.03	LT 0.03	LT 0.03	LT 0.03	LT 0.03	LT 0.03	LT 0.03	LT 0.03	LT 0.03
PO_4	0.08	0.31	0.31	0.55	0.25	LT 0.05	LT 0.05	0.8	0.61	0.18
BOD	2	2	2.5	7	7	3.5	2	10.2	10	4.5
COD	LT 20	27	16	27	94	27	31	47	43	20
Phenols	LT 0.05	LT 0.05	LT 0.05	LT 0.05	LT 0.05	LT 0.04	LT 0.05	LT 0.05	LT 0.05	LT 0.05

BH7A	BH8	BH9	BH10	BH10A	Stream leaving the site	Mire standing water	Bryn Posteg stream	Bryn Posteg spring	Bradnant Adit	Site stream by road	
7.4	7.3	6.6	9.6	9	5.8	6.1	7.3	7.0	6.8	6.9	pH
320	145	85	2050	2200	65	62	120	225	160	75	Electrical Conduct (micro mhos)
15	10	12	26	33	11	11	22	20	19	10	Chloride
94	18	22	26	46	18	18	28	96	60	16	Hardness Total
94	18	13	26	46	6	8	11	70	20	10	Carbonate
0	0	9	0	0	12	10	17	26	40	6	Non Carbonate
137	44	13	1050	1135	6	8	.11	70	20	10	Alkalinity
230	106	58	1450	1670	36	42	80	156	105	40	Dissolved Solids
LT 0.1	LT 0.1	0.8	1.7	LT 0.1	20.1	LT 0.1	1.6	2.4	7.1	0.4	Nitrate
0.30	0.23	0.29	0.28	0.60	0.21	0.25	0.12	0.18	0.20	0.16	Ammoniacal Nitroger
0.14	0.12	0.34	1.06	1.16	0.20	0.26	0.33	0.17	0.05	0.15	Albuminoid Nitroger
27	5	6	7	14	5	5	8	29	17	4	Ca
6	1	2	2	3	1	1	2	6	4	2	Mg
46	29	8	578	583	5	5	14	13	10	6	Na
2	2	1	5	6	1	1	1	3	1	1	K
82	26	8	630	705	4	5	7	42	12	6	CO_3
38	27	12	188	275	7	5	12	20	10	6	SO_4
15	8	12	26	33	11	11	22	20	19	10	Cl
0	0	4	8	0	0	0	7	12	32	0	NO_3
13	6	8	6	9	3	9	5	12	8	4	Si
7.5	2.45	10.2	7.3	40	0.63	2.09	10.8	8.8	1.17	7.6	Fe
0.07	0.10	0.20	0.17	0.30	0.17	0.17	0.11	0.07	LT 0.03	0.21	Zn
0.25	0.03	0.20	0.11	0.30	0.12	0.36	0.07	0.24	0.30	0.08	Cu
LT 0.03	LT 0.03	0.03	0.03	0.07	LT 0.03	0.09	0.03	LT 0.03	LT 0.03	LT 0.03	Pb
2.70	0.21	0.42	0.40	0.91	0.04	0.09	0.40	1.08	0.08	0.20	Mn
0.008	0.007	0.009	0.005	0.007	0.002	0.001	0.001	0.003	0.003	0.006	Cd
0.25	0.15	0.22	0.22	0.32	0.07	0.05	0.06	0.07	0.06	0.08	B
0.06	LT 0.03	0.13	0.14	0.16	0.06	0.11	0.13	0.10	0.10	0.15	Ni
LT 0.03	LT 0.03	LT 0.03	LT 0.03	LT 0.03	LT 0.03	LT 0.03	0.04	LT 0.03	LT 0.03	0.04	Cr
LT 0.05	32	0.8	0.8	1.6	LT 0.05	LT 0.05	0.37	LT 0.05	1.1	LT 0.05	PO_4
5	3	4	6	14	1.7	3.5	2	LT 1	3	2	BOD
24	LT 20	39	67	145	LT 20	43	28	LT 20	LT 20	LT 20	COD
LT 0.05	LT 0.05	LT 0.05	LT 0.05	LT 0.05	LT 0.05	LT 0.05	LT 0.05	LT 0.05	LT 0.05	LT 0.05	Phenols

CHEMICAL ANALYSES OF SAMPLES

TAKEN ON 21.2.1980

3. LANDFILL DESIGN

Having completed the full site investigation which indicated to Montgomery District Council a draft operational framework and landfill design, a brief was obtained to design the landfill in full. The detailed design for the development allowed for basic preparation works, under a Preliminary Site Works Contract, followed by periodic development of the site in five Phases over the 25 year site life. Figure 5 is a diagramatic presentation of the full scope of the development. The Preliminary Site Works and Phase One Preparatory Works were carried out as conventional Civil Engineering Contracts, and comprised the following sections whose costs are summarised in Appendix 3.

3.1 Preliminary Site Works

3.1.1 Site Works

This section comprised bulk earthmoving, gas main protection and mineshaft sealing. Although there was no apparent connection between the mine drainage and local streams it was considered prudent to seal the two mineshafts with reinforced concrete slabs, using the NCB specification for coal mines as a guideline. The original (No 1) shaft was, as anticipated, found to be 3 m diameter with rockhead at 5 m depth. The upper metre of shaft was excavated and refilled with a mass concrete plug, above which were placed blinding concrete and the capping slab, 6.45 m square and 0.45 m thick, containing 3.13 T of reinforcement. Before backfilling, a layer of clay 0.3 m thick was placed over the slab as a final leachate/gas barrier. The position of the mineshaft was marked with a concrete post, as tipping is restricted to inert materials for 5 m around the shaft. The most recent shaft (Old Engine Shaft) was found to be 5 to 6 m diameter, but tapering. Excavations were carried out to obtain a shaft diameter of 4.5 m, but as the NCB specification slab would have been six times the volume of the No 1 shaft slab, a new design was carried out to CP110 using the specific site loading conditions for a slab of 10 m length x average 4.5 m width x 0.7 m thickness, with 3.5 T of reinforcement. The other details were as for No 1 shaft.

A 150 mm diameter high pressure gas main crosses the site near to its western boundary, and forms the limit of the landfill on that edge. As the site entrance road crosses the main it was necessary to provide a slab to Wales Gas specifications to bridge the main. The slab was 11 m x 2.5 m wide x average 0.3 m thick, with mesh reinforcement.

The site originally contained a large quantity of mine spoil which, being rich in metals, was required by the Water Authority to be removed or isolated from the refuse. As the route of the access road passed through an area which would ultimately be raised it was decided to incorporate the mine spoil, which was generally broken shales, into an embankment to raise the road level to that of the final restored surface. As the final contours indicated a limited amount of infill external to the site it was decided to do this work in conjunction with the road fill. The total volumes for the earthmoving were 1950 m^3 of cut and 10300 m^3 of fill, including a quantity of shale obtained from an on-site borrow pit.

3.1.2 Surface Water Diversion and Drainage

As revealed by the site investigation the generation of leachate needed to be kept to a minimum, and one of the measures deployed was to construct a peripheral channel to intercept all surface water run-off and flows from the numerous field drains discharging onto the site. The channel was designed to carry a 1 in 5 year storm run-off at a velocity of 0.5 m/s; the design depth was 0.35 m, but this was increased to a minimum of 1 m to ensure the channel's continued operation. In addition, a deep channel was excavated into the mire to encourage drainage of the peat, and road drainage channels were provided as necessary.

The total length of the channels was 1850 m, and the volume of material excavated was 7270 m^3.

This section also included 115 m of french drain to intercept road run-off, 167 m of 225 and 300 mm overflow pipes from the lagoon and wheelwash, 61 m of 100 and 150 mm foul drain, 22 m of 500 mm road crossings, associated manholes and headwalls, a septic tank and soakaways. Flumes were provided to measure the flow in each arm of the interception system, and these together with recorded rainfall and metered pumped leachate discharges will be used to calculate the water balance from the site as part of a continuing research programme. A water main, 345 m of 50 mm dia UPVC pipe, was laid to connect with the proposed area service reservoir adjacent to the site.

3.1.3 Groundwater Diversion and Drainage

A further leachate reducing measure was the installation of a cut-off and drainage system to the shallow groundwater seepage system. This was installed initially around the lower half of the site (775 m) with a provision to increase the installed length if necessary around the remainder of the site. The system used was "Trammel", one of several systems available which incorporates a layer of woven permeable fabric allowing controlled infiltration to a central coarse bonded drainage layer, further infiltration being prevented by a subsequent layer of impermeable polyethylene. The system was installed against the side of the trench such that the intercepted groundwater passes down the central layer to a slotted 150 mm pipe laid up to 6.5 m below ground level. The pipe discharges 200 metres downstream of the site via a weir box into an adjacent stream. The flow to date has been approximately 40 m^3/day, or 16000 m^3/year. At an approximate and conservate cost of leachate disposal of £1/m^3 the system will have paid for itself within 3 years, assuming that the seepages would have otherwise entered the landfill.

3.1.4 Roadworks, Access and Cattlegrid

The earthworks for the road system have been described earlier. The site entrance road could not use the existing track because of leasing difficulties and because of inadequate visibility at the junction with the highway. The entrance road was constructed as a 5.5 m wide pavement of dense bitumen macadam from the highway to the site office (510 m), and as a 4 m wide hardcore road to the active cell and to the lagoon. It was decided that a 4 m wide tarmacadam road with passing places would not offer significant savings, as the bulk of the earthworks, being on the corners, would in any event require to be 5.5 m wide to permit refuse vehicles and low-loaders to negotiate the tight radii. The 25 year site life, and the extremes of weather conditions experienced at Bryn Posteg, do not allow consideration of anything other than a waterproof surfacing. In accordance with the Planning requirements, a car park, turning bay, wheelwash and amenity skip area were provided in the road network, together with a cattle grid designed to Ministry of Agriculture guidelines. The gateposts between the grid and the grid bypass are removeable to permit the entry of low-loaders carrying plant.

3.1.5 Wheelwash

Planning requirements specified the provision of a wheel cleaning area. It was felt that a system which did not rely on external power sources would be desirable, and after consideration of the available alternatives it was decided to construct a "dip" type wheelwash, comprising a submerged grid 5 m long with 5 m long entry and exit ramps, the submerged length being approximately 7.5 m, with a depth of immersion between 250 and 300 mm, controlled by a weir chamber. De-sludging is by a disc flushing valve set 1 m below the grid level. The cost of the wheelwash was approximately half the capital cost of the pressure jet alternative.

3.1.6 Leachate Treatment Lagoon

Calculations of leachate generation indicated that the maximum flow rate would be 100 m^3/day. In order to reduce the trade effluent charges payable for discharge at the STW it was decided to construct a pretreatment plant, comprising an aerated lagoon and post aeration settlement. A mimimum retention time of 10 days was adopted, giving a capacity of 1000 m^3. In order to treat a leachate with a COD of 10 000 mg/l and a BOD of 7 000 mg/l by removing half of the BOD, an oxygen uptake of 350 kg/day would be required. Based on a transfer efficiency of 1.4 kg/hr/KW and an oxygen coefficient of 1.5 this required an aeration capacity of 375 KWh/day, or 17 hours per day for two 11 KW aerators. The remaining 7 hours of each day would be used for settlement and pumping of the treated leachate to the Llanidloes sewerage system at the maximum acceptable rate of 5 l/s. Two floating aerators were chosen to ensure adequate mixing, and for simplicity of operation.

Draw-off of the top 150 mm of settled effluent will be via a fixed bellmouth to a standard manhole equipped with a submersible pump. The control equipment provides manual start/stop with auto star/delta starting of aerators, low level and safety cut-outs, and interlocks to prevent simultaneous aerator and pump operation. It is possible that automatic time controlled starting may be introduced in future to permit shorter treatment cycles.

The lagoon itself is constructed in the natural clay and shale materials and is 3 metres deep with 1 m freeboard, with side slopes of 1:2½ internally and 1:2 externally. A liner of 1.5 mm HDPE is installed to prevent erosion damage and as a safeguard against leachate seepage. De-sludging is provided for using a hydrostatic discharge. It is calculated that pretreatment may achieve a net saving in overall leachate disposal costs of £0.5/m^3, or £18250/year at maximum generation rate. Lower generation rates should of course achieve a higher standard of treatment.

3.1.7 Fencing, Tree Planting and Seeding

The site is bounded by a 1685 m long security fence of 50 mm galvanised chain link with 3 strands barbed wire on 2 metre high cranked posts, with 2 x 3 m wide pairs of gates.

The outline landscape design which we produced using an expert landscape architectural input, and which was accepted by the Planning Department, included a comprehensive tree screen around the site. Part of this is to be planted on the restored surface of Phase One of the landfill, but the initial development included the planting of some 440 Beech, Pine, Spruce, Rowan, Alder and Sycamore in rows and groups around the site. In addition to this, the lagoon flanks and selected areas of road verge were topsoiled, and these areas and the surface water channels were then seeded.

3.1.8 Miscellaneous Items

Entrance, road and warning signs in Welsh and English were erected at appropriate locations. A concrete slab was placed for the permanent site cabin, and a slab and plinths were constructed for the fuel storage tanks.

3.2 Phase One Preparatory Works

3.2.1 Earthworks

The development of Phase One entailed the stripping of topsoil from Phase One and from the designated clay stockpile areas, totalling 12900 m^3, and the excavation to 5 m depth of the maximum available volume of clay from the Phase consistent with the retention of a minimum depth of 1 m of clay below the site. Certain areas were deficient in clay, and were therefore raised in compacted layers to the required thickness. In addition, 2 metre bunds were raised to contain refuse and leachate, and to minimise the catchment area of the active cell. The total volume of clay excavated was 31 500 m^3, 24 400 m^3 being stockpiled for future sealing and capping and the remainder being used in bunds and deficient areas.

3.2.2 Leachate and Surface Water Drainage

This section comprised the excavation of a shallow ditch upstream of the Phase boundary, and adjacent to the Phase access road, and the construction of 4 leachate control manholes and connecting pipes, to allow the abstraction of leachate and future control of leachate flows between Phases. A 375 m long 80 mm diameter uPVC rising main was laid to the treatment lagoon.

3.2.3 Phase One Access Road

The site entrance road was extended to Cell One of Phase One by a 195 m long 4 m wide access road with two passing bays. The road construction was 250 mm of Type 1 sub-base on a minimum thickness of 400 mm of shales obtained on site, placed on a layer of separation membrane over natural sub-soil.

3.3 Programme

The construction period lasted approximately 12 months, commencing on 13 July 1981. The site opened on schedule on 28 June 1982, though minor works have continued sporadically since that time. The Main Contractor for both Contracts was Alun Griffiths (Contractors) Ltd, and the Nominated Sub Contractors for the Preliminary Site Works Contract were Whitehead and Poole Ltd (Aerators, Pumps and Controls), Butyl Products Ltd (Lagoon Liner) and Severn Vale Seeding Company (Fencing and Planting).

3.4 Environmental Monitoring

The site is now operational and an environmental monitoring programme has been approved by Montgomery District Council so that both the performance of the landfill and its impact on the external environment can be monitored. Both the Welsh Office and the Department of the Environment are supporting further Research and Development activities being carried out by Montgomery District Council and their Consultants.

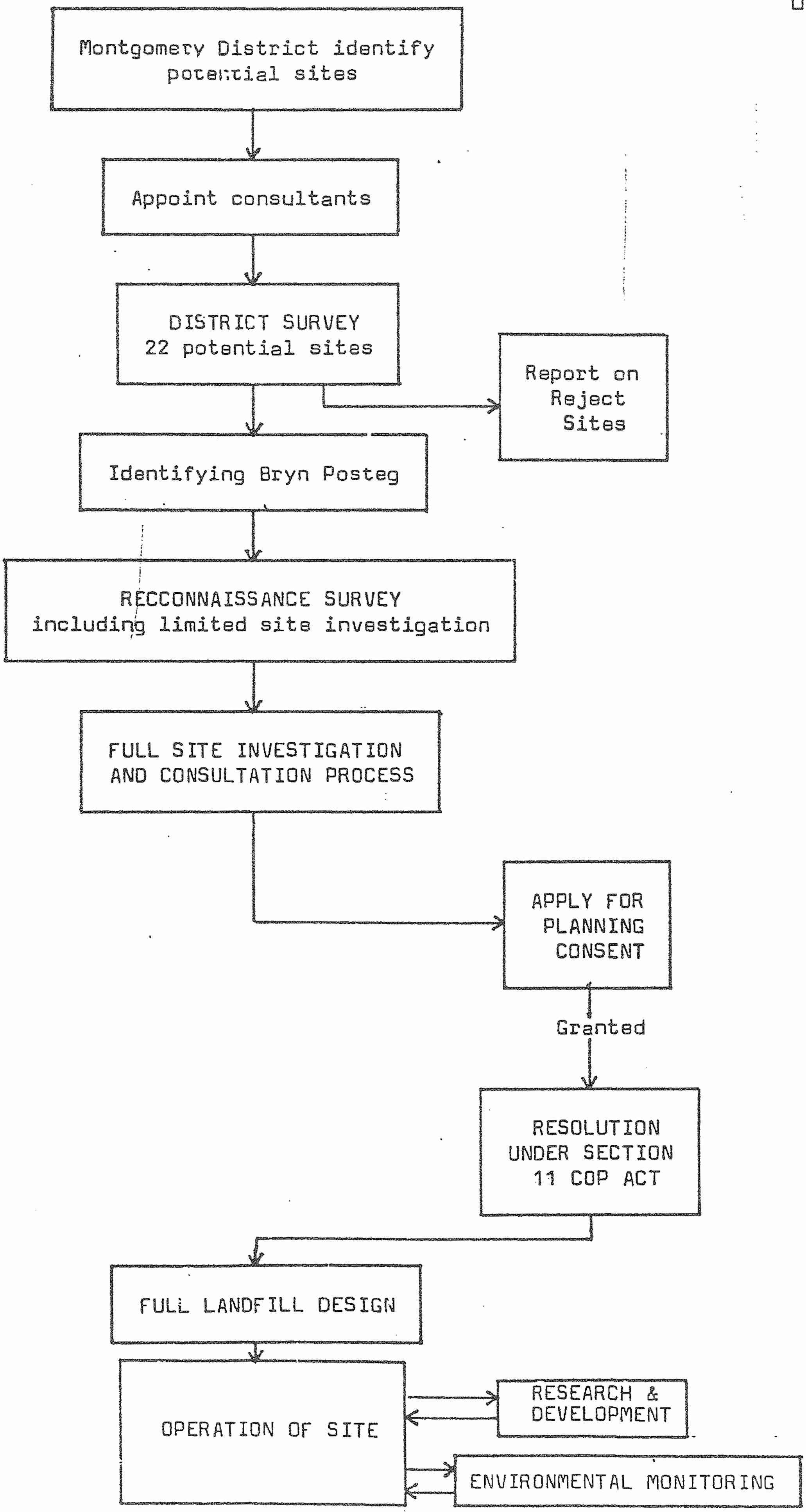
TABLE 1

Summary of Costs

Category	(Preliminary Site Works)	Contract Price (£)
1	Preliminary Items	13350.00
2	Mineshaft capping	7812.71
3	Roads, earthworks, infill, access, cattlegrid	61507.83
4	Surface water diversion and drainage	27003.73
5	Groundwater diversion and drainage	42856.12
6	Wheelwash	5382.65
7	Lagoon and Pipework (Civil work + lining)	21170.09
8	Aerators, pumps and controls	24840.39
9	Electricity supply	7794.00
10	Fencing	11851.77
11	Tree planting, seeding and topsoiling	4530.45
12	Site signs	843.58
13	Miscellaneous items, (trialholes, gas main protection)	835.67
14	Additional items, (diesel tank plinths, etc)	1610.62
	TOTAL PSW	231389.41
	(PHASE ONE)	
15	Preliminary items	8500.00
16	Earthworks	38469.80
17	Leachate and surface water drainage	11923.70
18	Access road	5669.83
	TOTAL PHASE ONE	64563.33

FIGURES

BRYN POSTEG FLOW CHART OF LANDFILL DEVELOPMENT



STAGES IN THE INVESTIGATION OF LANDFILL SITES

Preliminary Date Appraisal

Geological
- Solid geology
- Structural geology
- Superficial geology

Hydrological
- Water abstraction
- Water Authority attitudes
- Stream characteristics
- Aquifer characteristics
- Springs/seepages

Meteorological
- Rainfall-annual
- Intensity duration
- Evapotranspiration

Mining/quarrying
- Old Plans
- Extent of deposit/ workings
- Type/quality of spoil

Legal
- Abstraction/discharge licenses
- Relationship with other owners
- Easements

Physical
- Site capacity
- Boundaries
- Access

Market
- Arisings of Domestic and Industrial Waste

↓

RECONNAISSANCE REPORT

↓

Initial feasibility analysis Accept/Reject → Reject Site unsuitable

↓

Full Site Investigation

Topics covered may include:

Groundwater
- Define distribution of water bearing and non water bearing strata (aquifers and aquicludes)
- Define extent of saturated and unsaturated zones
- Define pattern of groundwater flow
- Establish the hydraulic properties of the strata
- Establish the ion-exchange characteristics of the strata
- Establish existing groundwater quality
- Establish all groundwater abstractions from boreholes, wells and springs
- Establish extent of unsaturated zone
- Locate all discharges to groundwater

Surface Water
- Define pattern of surface water flow
- Establish flow characteristics of surface water streams
- Establish existing groundwater quality
- Locate all surface water abstractions from streams
- Locate all discharge to streams

Cover Materials
- Define distribution of cover
- Establish physical characteristics of cover

Physical
- Carry out full topographical survey of site area

↓

REPORT
including outline landfill design

↓

Feasibility analysis Accept/Reject → Reject

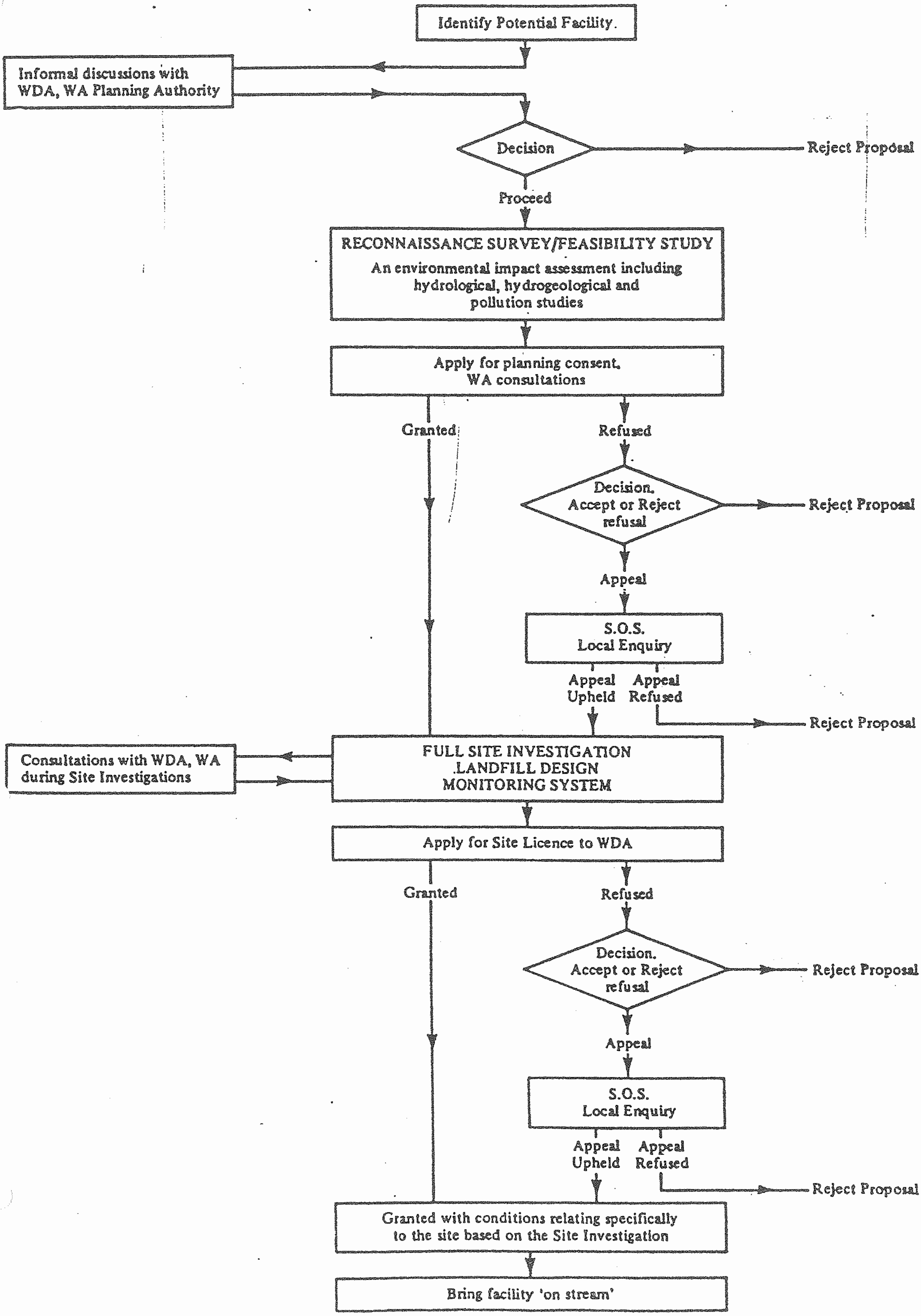
↓

FULL LANDFILL DESIGN

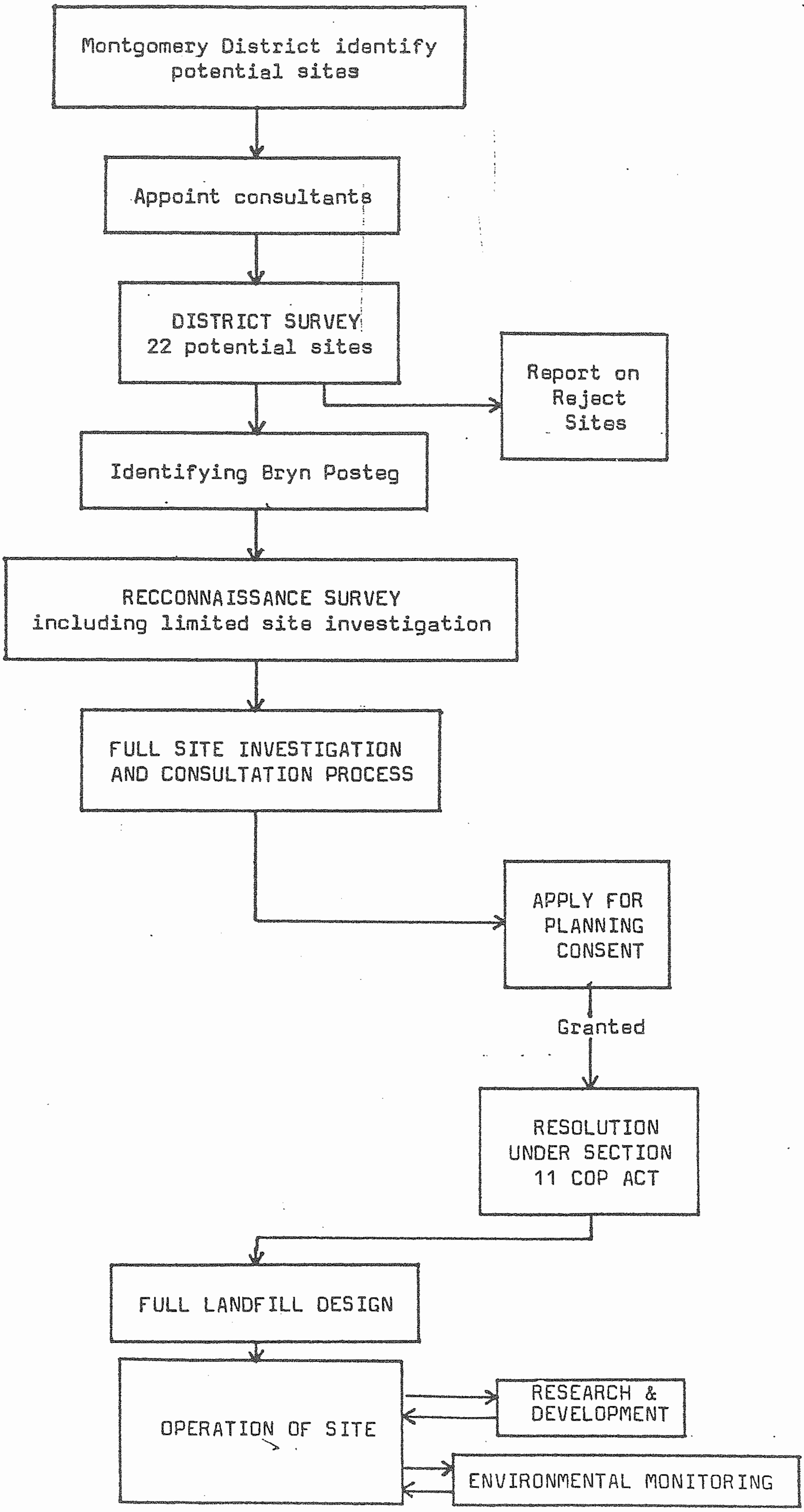
Including monitoring system for
waste types and quantities,
leachate production and quality
landfill gas production and quality

↓

LICENSING/PLANNING DECISION ROUTE



BRYN POSTEG FLOW CHART OF LANDFILL DEVELOPMENT



APPENDIX 4

STEP 1 is RC > 10% EQS

RC- Effluent concentration ug/l

	Units	RC	EQS	10%EQS	RC>10%EQS
Ammoniacal Nitrogen	ug/l	250	300	30	FAIL
Iron	ug/l	7000	1000	100	FAIL

STEP 2 is PC<4% EQS

where PC = EFR*RC/(EFR+RFR)

EFR - effluent flow rate	0.05	m3/s	max treatment capacity
RFR - rvier flow rate	1.01	m3/s	Q95 River Severn

PC process contribution

	Units	RC	PC	EQS	4%EQS	PC > 4%EQS
Ammoniacal Nitrogen	ug/l	250	11.79245	300	12	PASS
Iron	ug/l	7000	330.1887	1000	40	FAIL

STEP 3 is (PEC -BC) > 10%EQS

where PEC=((EFR*RC)+(RFR*BC))/(EFR+RFR)

BC - background concentration

	Units	RC	BC	PEC	PEC-BC	EQS	10%EQS	PC > 4%EQS
Ammoniacal Nitrogen	ug/l	250	200	202.3585	2.358491	300	30	PASS
Iron	ug/l	7000	5180	5265.849	85.84906	1000	100	PASS

If PEC is calculated by PC +BC 5510.189

STEP 4 is PEC > EQS

	Units	RC	BC	PEC	EQS	PC > 4%EQS
Ammoniacal Nitrogen	ug/l	250	200	202.3585	300	PASS
Iron	ug/l	7000	5180	5265.849	1000	FAIL

NOTE: Natural background concentrations fail the EQS pre landfill development

GROUNDWATER PRE LANDFILL

	pH	NH4-N (mg/l)	Fe (mg/l)	BOD
BH1	6.1	0.09	5.2	2
BH2	9.5	0.15	21.2	2
BH3	7.8	0.17	3.11	2.5
BH4	8.1	0.14	4.5	7
BH4A	7.6	0.42	10.1	7
BH5	7.2	0.01	4.1	3.5
BH5A	7.1	0.15	2.61	2
BH6	7.4	0.25	25.7	10.2
BH6A	8.3	0.22	3.59	10
BH7	7.4	0.32	2.56	4.5
BH7A	7.4	0.3	7.5	5
BH8	7.3	0.23	2.45	3
BH9	6.6	0.29	10.2	4
BH10	9.6	0.28	7.3	6
BH10A	9	0.6	40	14
Average	7.76	0.241333	10.008	5.513333

SURFACE WATER PRE LANDFILL

	pH	NH4-N (mg/l)	Fe (mg/l)	BOD
Mire Standig water	6.1	0.25	2.09	3.5
Bryn Posteg Stream	7.3	0.12	10.8	2
Bryn Posteg Spring	7	0.18	8.8	1
Bradnant Adit	6.8	0.2	1.17	3
Site Stream by road	6.9	0.16	7.6	2
Stream leaving the site	5.8	0.21	0.63	1.7
Average	6.65	0.186667	5.181667	2.2

Summary Parameter Table

	Chemical Na	niacal Nitrog	pH	**BOD**	**Suspended solids**	**Iron**	**Aquatreat**	**Justification**
Units		mg/l	-	mg/l	mg/l	mg/l	-	
Discharge (2016 -2018 site data)	**min**	0.1	6.2	1	1			No data for Iron – back calucaltion to determine acceptable concentration. ,See above for site data
	Average	0.1	6.9	1.6	8.2			
	95%ile	0.1	7.5	4	30			
	max	13.6	7.8	10	38			
	count	34	34	34	34			
Maximum Flow L/S		50l/s						Maximum treatment rate
Average Flow L/S								No average flow data
Fresh Water upstream	Maximum Co	0.3	7.3	3.5		10.8		See above tables for SW
	Average Con	0.2	6.6	2.2		5.18		
	Min Conc	0.1	5.8	1		0.6		
LOD								
EQS	Annual Avera	ND	ND	ND	ND	1		
	MAC	ND	6-9	ND	ND	ND		

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