CROWNHILL TOPSOIL PRELIMINARY GROUND AND SURFACE WATER RISK ASSESSMENT REV1 - 2020

Unit 1009, Caerwent Army Training Estate, Caerwent

Produced by: EcoVigour
info@ecovigour.com

Title	Crownhill Topsoil – Groundwater Risk Assessment		
Location	Unit 1009 Caerwent Army Training Estate		
Document Ref	Groundwater Risk Assessment CH017	**Issue / Revision:** Draft for Comment	00
File reference	CH007		
Date	19/06/18		
Prepared by	David Findon	Signature	Date 19/06/18
Checked by	Julian Gregory	Signature	Date 04/04/19
Authorised by	Julian Gregory	Signature	Date 10/04/19

Rev	**Date**	**Purpose**	**Prepared by**	**Checked**	**Authorised**
01	07/01/20	Address comments from Schedule 5 Notice received 06/12/19	Julian Gregory	Brad Stokes	Simon Stone

Contents

Introduction

Ecovigour Ltd were commissioned by Crownhill Topsoil and Aggregates in 2018 to prepare a ground and surface water risk assessment in support of an application for a Bespoke Environmental Permit based on the following Standard Rule Set SR2010_No12 – Treatment of Waste to produce Soil, Soil Substitutes and Aggregates. This document is an update on this report incorporating information from surface and ground water monitoring, undertaken at the site in November 2019.

The permit application is for the operation of an inert waste recycling facility for the production of soils and aggregates from inert wastes.

Site Location

The site is located at Unit 1009 within the Caerwent Army Training Estate. The site occupies an area of around 6ha in the north west of the estate. There are a number of brick and concrete built buildings within the boundary of the site which have previously been used for compost production. This site is a combination of hard covered and permeable areas within the secure confines of the Army Training Estate. The site is secure against unauthorised access with all traffic entering and leaving the site passing through a manned security barrier.

FIGURE 1: SITE LAYOUT

Scope of Work

This report initially details the geology, hydrogeology and hydrology of the site. This information is then utilised to produce a groundwater risk assessment in accordance with the Risk Assessments and Groundwater Risk Assessments Guidance produced by the Environment Agency and The Department for Environment, Food and Rural Affairs (DEFRA) in February 2016. This guidance has replaced the H1 Environmental Risk Assessment tool and guidance which was withdrawn in February 2016. These guidance notes outline the following requirements:

- Source/Pathway/Receptor Approach
- Conceptual Model
- Tiered Risk assessment

Risk Assessment Methodology

As per the Environment Agency guidelines, this risk assessment follows a strict methodology to ensure it is thorough and accurate. This methodology comprises of the following steps:

Desk Study

The desk study utilises all available geological maps, historical maps, hydrological maps and previous site investigation/condition reports to generate a thorough understanding of the environmental setting of the site. The desk study includes a water features survey, which identifies any private and licensed groundwater abstractions within proximity to the site.

One of the primary objectives of the desk study is to identify all possible sources, pathways and receptors for the site. These are listed and described in detail, which allows risks to be easily identified and subsequently mitigated.

Conceptual Model

A conceptual model can be created once the above have been identified. Groundwater Protection: Principles and Practice (GP3) states that a conceptual model is "a simplified representation or working description of what we believe to be the physical, chemical and biological processes operating at a site or study area.". This usually takes the form of an annotated diagram outlining the processes taking place at the site.

Risk Assessment

The guidance recommends the use of a tiered approach, which ensures that time and effort is correctly utilised where required. The guidance identifies 3 tiers:

Tier 1 – qualitative risk screening – investigate what the risks are, whether more detailed assessment is needed and what that would need to focus on (risk prioritisation). This involves carrying out basic calculations to predict dilution factor within the mixing zone beneath the site, as well as the attenuation factor for each substance.

Tier 2 – generic quantitative risk assessment – to collect more information an informed decision can be made regarding the risk posed by the site. This includes the use of hydrogeological calculations to predict the level of attenuation present for the discharge to ground under worst-case scenario.

Tier 3 – detailed quantitative risk assessment – to collect more information and formulate a plan if there are clear source-pathway-receptor relationships. This involves a detailed assessment of groundwater, the attenuation processes present, as well as using probabilistic calculations to assess what outcomes of certain scenarios may be.

Compliance points must also be identified. These are important in ensuring that the contaminant concentrations do not reach unacceptable levels. Compliance points are monitoring locations, such as boreholes, which must be located in a position which will accurately assess the nature of the site's impact on the groundwater. Limits of concentration must be set based on environmental standards, if these are exceeded action must be taken.

Principle Source

This study is based on information gained during the following studies undertake at the site:

Tier one groundwater and surface water risk assessment undertaken by SKM Enviros as part of a Land Quality Assessment in 2014;

DTE Caerwent – Former Wormtech Area LQA2 Addendum – Jacobs – July 2016;

DTE Caerwent – Former Wormtech Area LQA2 Addendum – Jacobs – November 2019.

Desk Study

Much of the desk study is based on reports generated by data searches undertaken by Groundsure in November 2016. These provide data on geology, hydrogeology, hydrology and site history. More detailed information regarding groundwater location, flow and composition has been obtained from the Land Quality Assessments of the site undertaken of by SKM Enviros and Jacobs. These reports include risk assessments for the impact to groundwater and surface water the results of which are outlined in this report.

Site History

The site is located on an Army training facility, which has been utilised by the military since 1939, initially as a propellant factory, then from 1968 until 1993 a US Army Reserve Storage Depot, and finally utilised as a training facility, which continues to this day.

The exact nature of the use of the site during the time when it was used by the MoD is not known, but from the nature of the buildings and the position of Unit 1009 on the periphery of the site it is likely that the site was constructed during the latter stages of the development of the army base and was used for storage.

Between 2006 and 2012, the site was occupied by Wormtech, company specialising in the composting of green waste, and later food waste. Systems were initially put in place by Wormtech to prevent contamination. The operations were carried out on hardstanding, and runoff from waste stockpiles was piped to a lagoon, from which the water was pumped into tankers and removed from site. In the later stages of Wormtech's operations, more waste was accepted than was processed and removed. This resulted in large stockpiles being left on site. The hardstandings, particularly the roads, deteriorated due to wear. Similarly, the piping systems showed evidence of leakage and failure. As a result, runoff from the stockpiles caused a significant impact on surface and groundwater. The environmental consequences of the site prompted the shutting down of the business. No remedial action was undertaken by Wormtech, who left the stockpiles of green waste on site. All food waste and a large amount of green waste was removed from the site by the Welsh Assembly Government in 2013.

Historical mapping of the area is severely limited due to the site's past military use. The oldest map in which the site is shown to have roads and structures present is 2002. Prior to this, all mapping shows the site being located across two agricultural fields. The military base has been present at this site in some form since 1939.

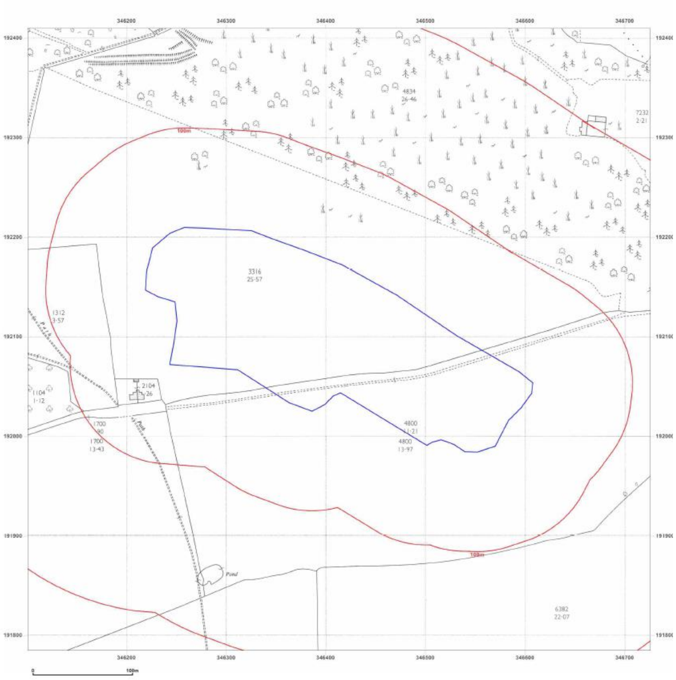


FIGURE 2: OS MAP OF SITE 1964

Although historical maps of the area remain predominantly unchanged until recently, the Groundsure data search returned data regarding potentially contaminative historical land features and historical ground works information.

The search did not identify any potentially contaminative land within the site boundary. It did however identify a number of areas of "Potentially Infilled Land", including cuttings and unspecified heaps within 500m of the site boundary. There was also an unspecified mill 193m south west of the site, and a number of quarries and kilns located over 350m from the boundary. These are predominantly clustered in the south/south east, although two disused mills were identified 452m to the north of the site.

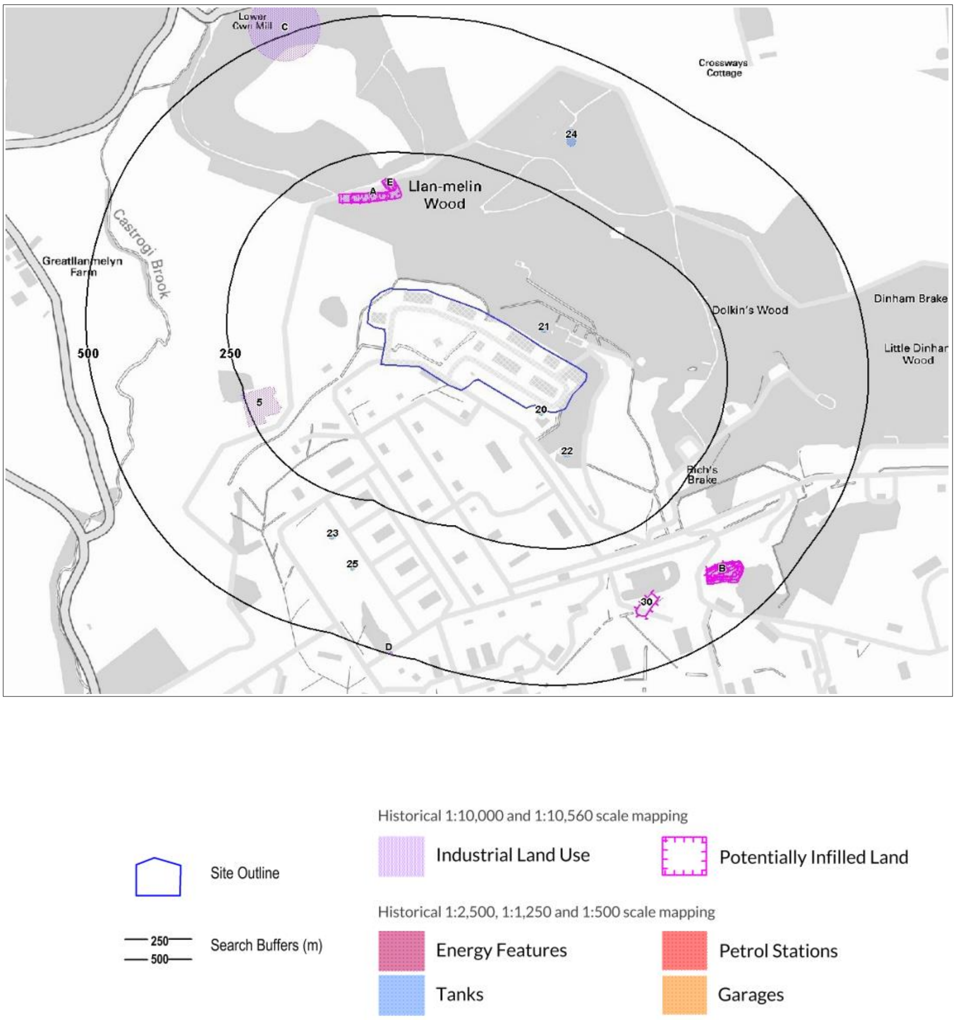


FIGURE 3: HISTORICAL INDUSTRIAL SITES

The data search also returned 5 records of pollution incidents within 500m of the site. 4 of these were located on site, and occurred in October 2012, all of which are identified as occurring within the site boundary. These were listed as having a significant impact on the land, with a minor impact to water. There was also a pollution incident in November 2010 which had significant impact on both land and water, with minor impact to air. This was located 325m south west of the site. These incidents coincided with the presence of the Wormtech composting facility on site, which was run between 2006 and 2012.

FIGURE 4: POLLUTION INCIDENTS AT SITE

The data search returned 4 waste treatment licenses for the Wormtech composting facility on site. No other waste treatment, transfer or disposal sites were identified within 500m of the site.

FIGURE 5: WASTE SITES

The Groundsure report identified two historic mining areas within 1000m of the site. The first was located 193m south west of the site. The second was 612m to the west of the site. Both records were from 1902 and do not specify mining type.

FIGURE 6: HISTORICAL MINING

Geological Setting

The geology of the site has been identified through both the data search undertaken by Groundsure and reviews of the Land Quality Assessment report carried out by SKM environmental and the 2016 and 2019 addendums completed by Jacobs. These identify river terrace deposits to the south west of the site. These deposits consist of clay, silt, sand and gravel, and cover most of the south west of the army training facility. Clays and gravels are present to a depth of 4 - 6m, as identified by trial pits and boreholes utilised for the SKM report. The superficial deposits across the site have been identified as having low to moderate permeability.

FIGURE 7: SUPERFICIAL DEPOSITS

The bedrock geology of the area is composed of Carboniferous Limestone, specifically the Black Rock Limestone Subgroup (Dolostone) and the Gully Oolite Formation. There is a fault which runs through the site from north to south in the east of the site. There is also a fault to the north, which runs perpendicular with the fault which bisects the site, intersecting north of the boundary.

The data search identified that the permeability of the bedrock underlying the site is between high and very high. This is due to the presence of the faults and fractures present within the rock formation.

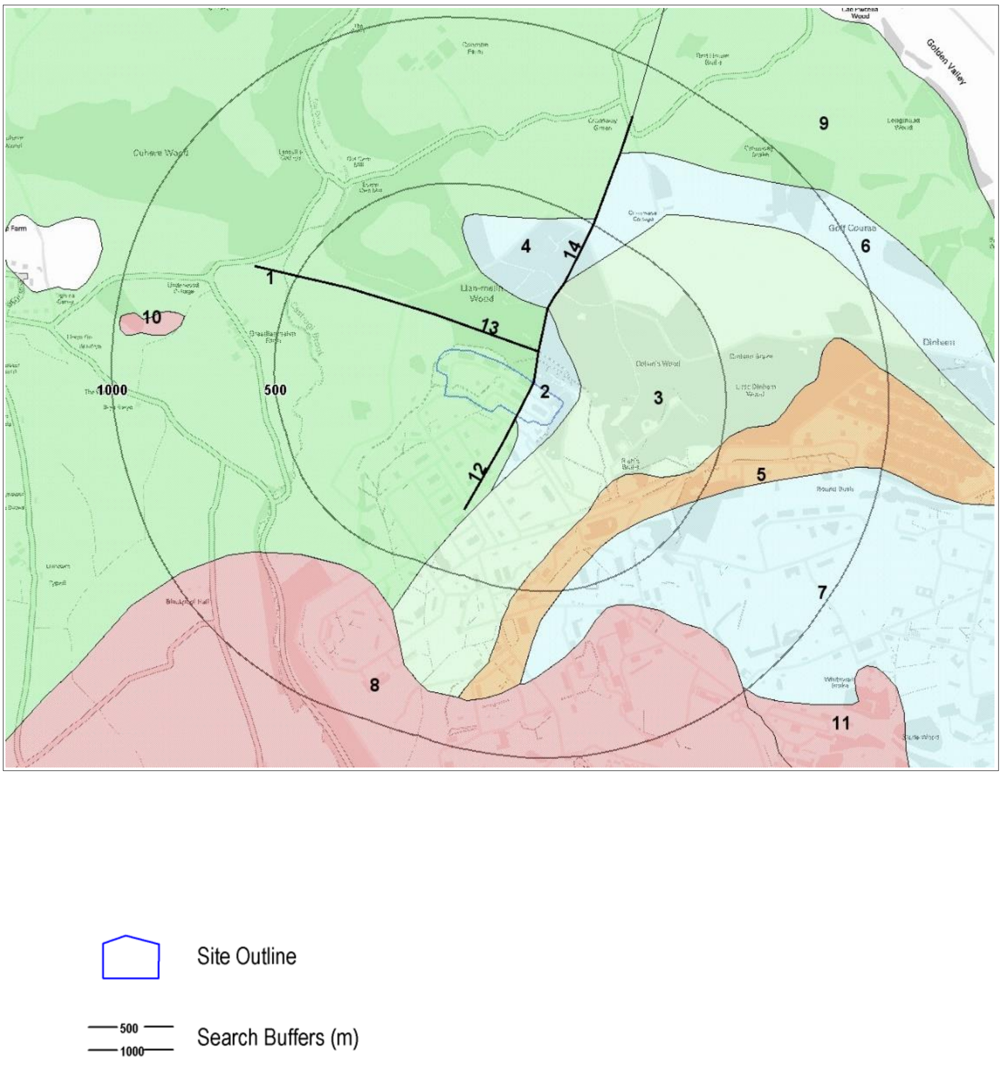


FIGURE 8: BEDROCK GEOLOGY

Hydrogeological Setting

The superficial deposits present on site have been designated as "unproductive". It has been identified that these deposits have low permeability, and as such have negligible significance for water supply or river base flow.

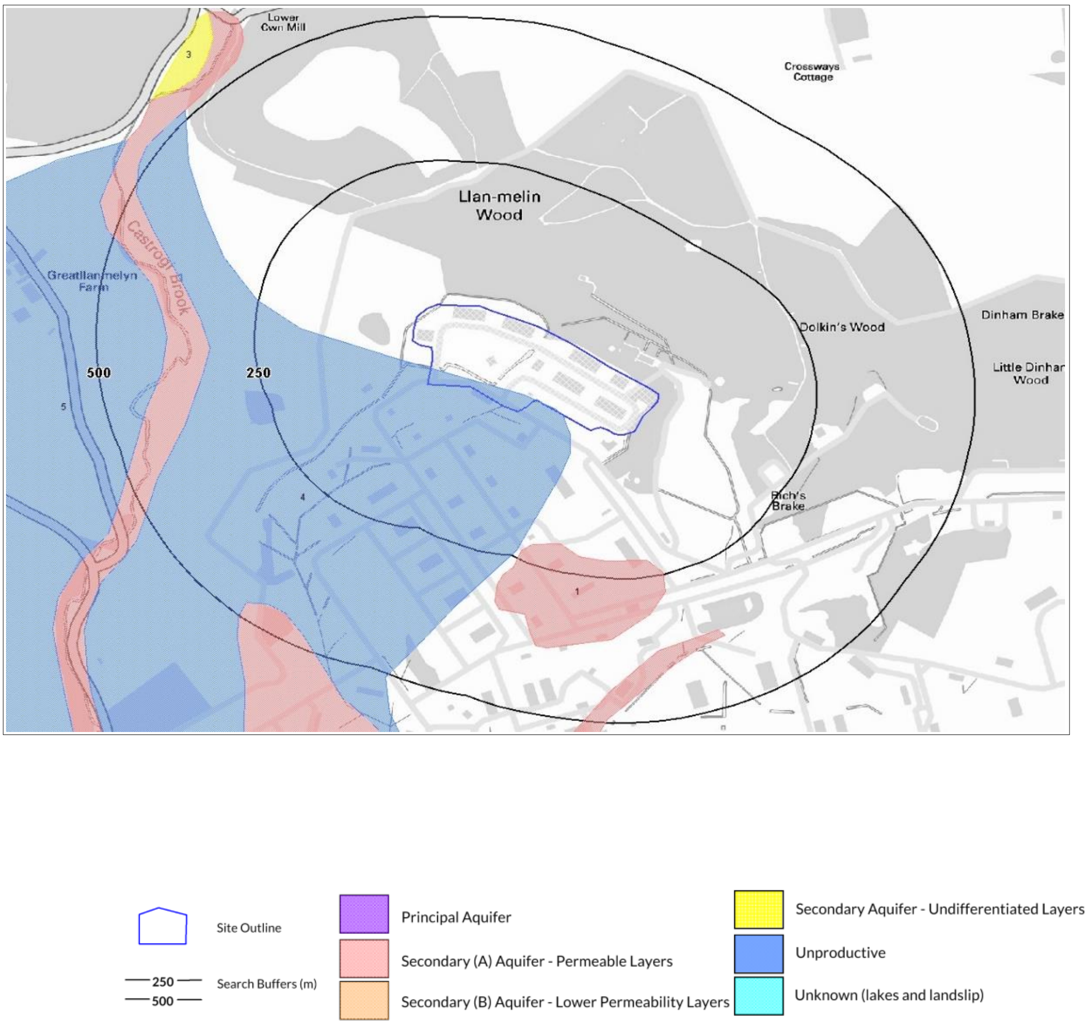


Figure 9: Aquifers Within Superficial Geology

The bedrock has a high level of permeability. It has been designated as a "Principle Aquifer" by the data search, which is defined as "Geology of high intergranular and/or fracture permeability, usually providing a high level of water storage and may support water supply/river base flow on a strategic scale. Generally principal aquifers were previously major aquifers". This principle aquifer forms part of the source protection zone (SPZ1) for the Severn Tunnel Great Spring Abstraction at Sudbury.

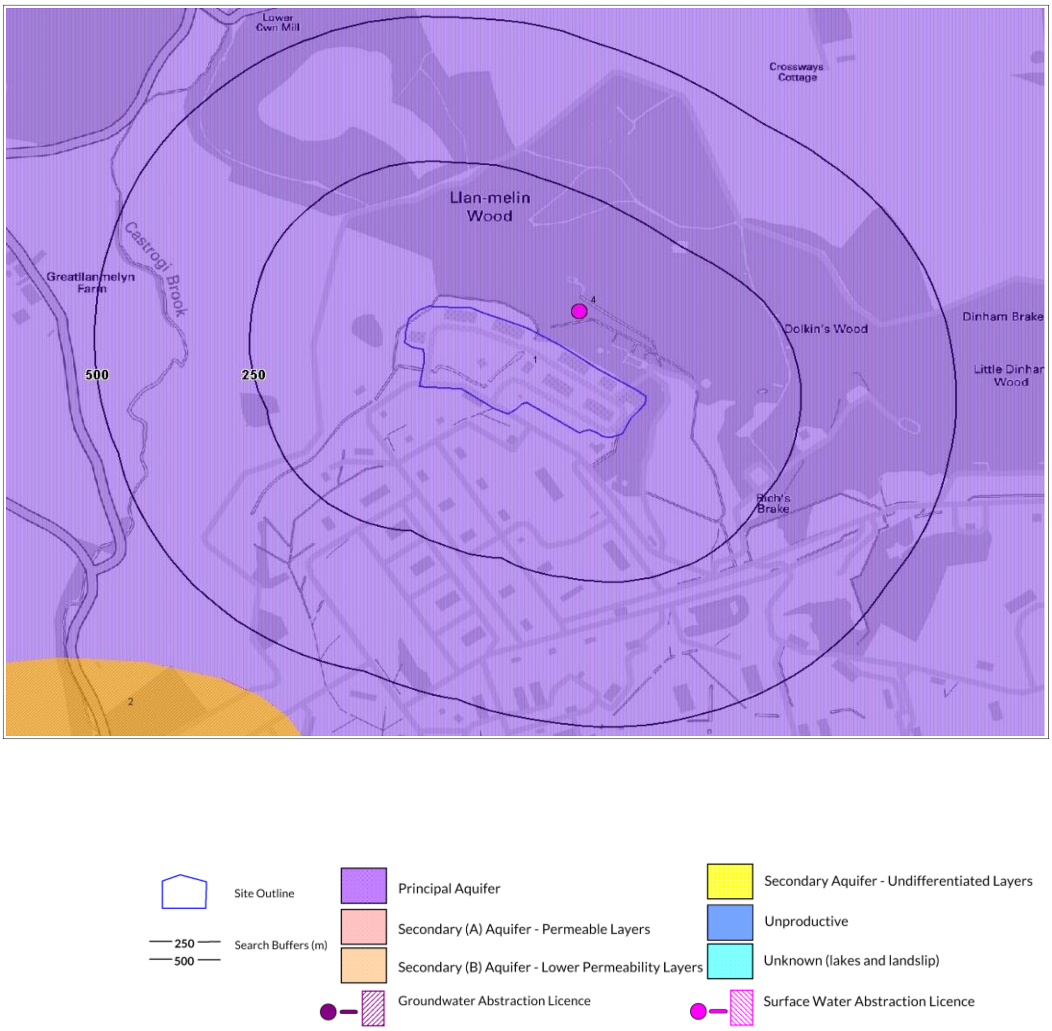


FIGURE 10: AQUIFERS PRESENT IN UNDERLYING GEOLOGY

The 2014 Land Quality Assessment established 11 groundwater monitoring locations to establish and then enable monitoring of groundwater conditions at the site. These boreholes were ten monitored in July 2014 and November 2019 (some of the boreholes had been removed or damaged by this point meaning that samples could not be taken) The following information is provided by reporting from these studies:

- The general direction of groundwater movement is southerly at the site;
- Water levels tend to be higher on the northern side of the site;
- During periods of low rainfall, there are substantial variations in groundwater level, often over short distances, suggesting the aquifer is not laterally consistent with the water table;
- During periods of high rainfall, this is not the case, with levels being fairly uniform, as shown in figures 11 and 12 (rainfall was consistently high between 25th November and 10th December 2014);

- Two of the boreholes within close proximity to each other (122m) differed by up to 5.9m, which suggests the fault near the lower-level borehole is increasing the flow rate of the groundwater.

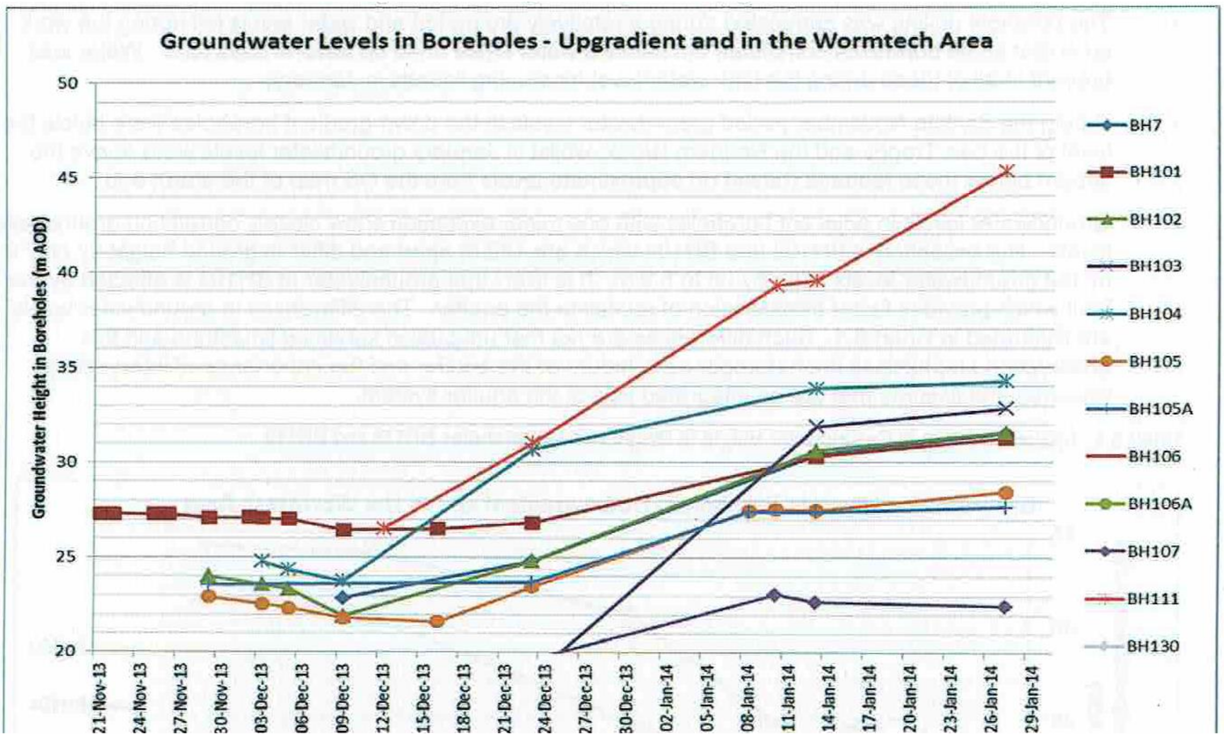


FIGURE 11: GROUNDWATER LEVELS IN BOREHOLES UPGRADIENT OF SITE

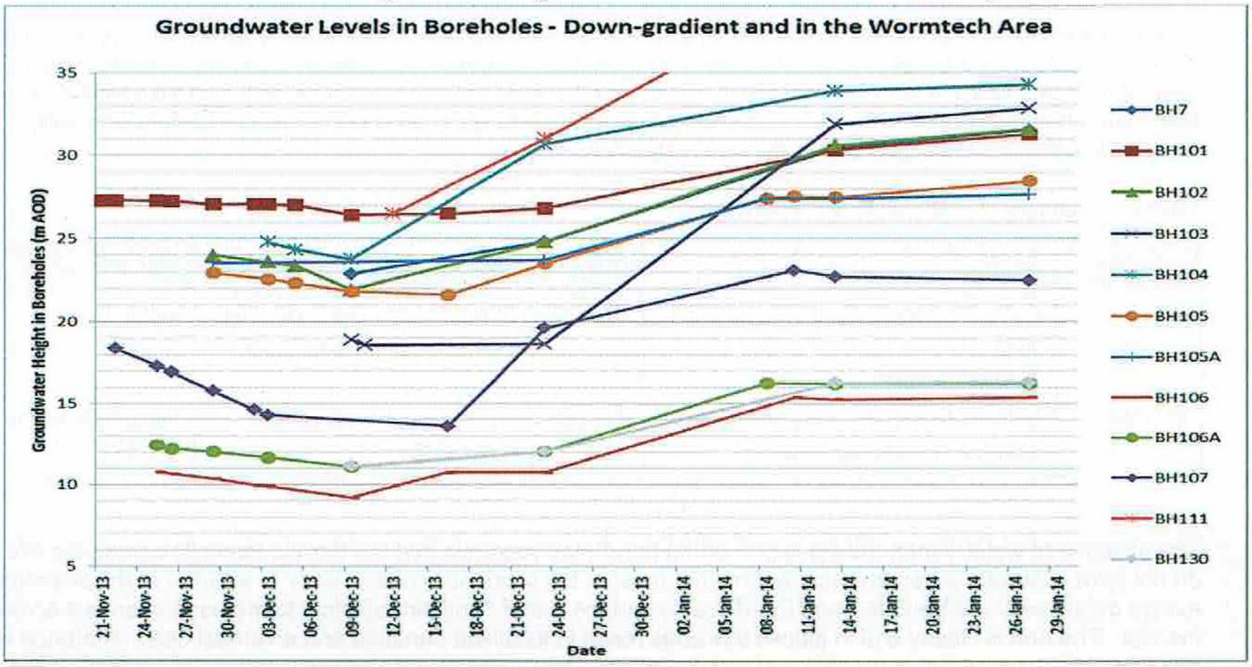
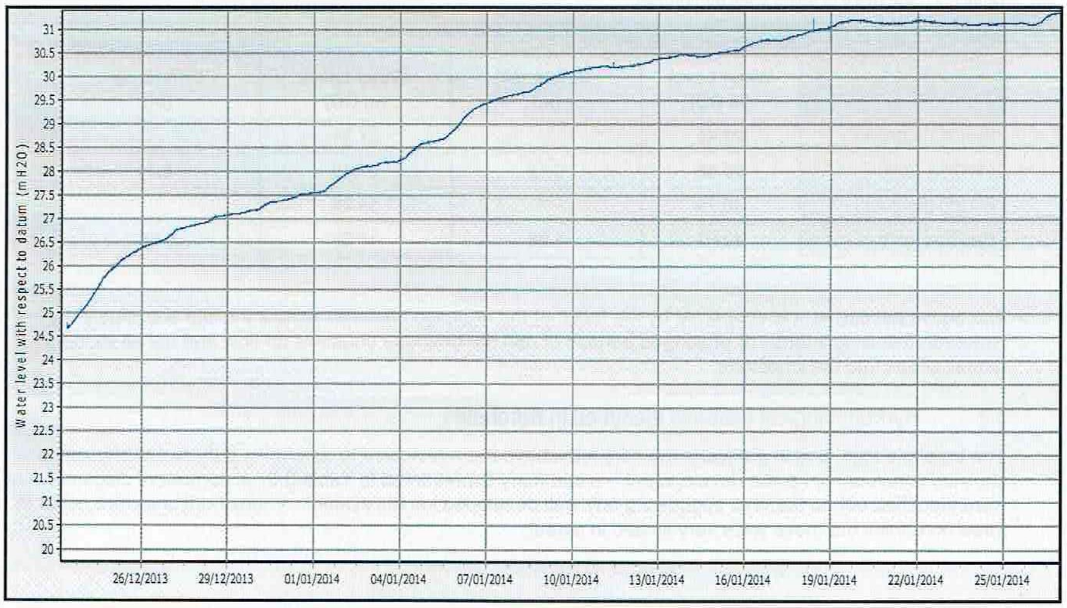


FIGURE 12: GROUNDWATER GRADIENT IN BOREHOLES DOWNGRADIENT OF SITE

The SKM report found that the recharge at the site is dominated by dispersed recharge from incident rainfall across the site, rather than fast recharge and discharge associated with fast moving, highly permeable geology. This can be seen in Figure 12 where there are no significant peaks or troughs.



Borehole logs also identify that there appears to be a number of small perched watertables within the site boundary where the material above the limestone becomes very clay-heavy. These are predominantly located in the south west and south east of the site, and do not carry a great deal of water.

No groundwater discharges have been identified on site.

There are no groundwater abstractions present in the vicinity of the site. There are 4 abstraction locations which have been identified down gradient of the site. These are:

- Phillips Abstraction;
- Broome & Co Ltd Abstraction;
- Marriott St Pierre Hotel & Country Club Abstraction;
- Severn Tunnel Great Spring Abstraction.

The most significant of these is the Severn Tunnel Great Spring Abstraction, which is located 6km SE of the Crownhill site. This is used for drinking water.

The SKM and Jacobs reports identify several exceedances in the groundwater quality. The contaminants in question were ammonia, manganese, BOD and iron. These are localised to the site and are not present downgradient. Monitoring data demonstrates that the level of contamination has significantly reduced during the 6 years of monitoring undertaken due to the removal of some of the compost as part of the original trials, the movement of wastes and turning of them to allow the compost to mature aerobically and the maturation of the compost to a more stable state.

Crownhill Topsoil and Aggregates have no current plans to utilise more of the compost, due to the complexity this adds to the Environmental Permitting process.

Hydrological Setting

As with much of the Army Training site, there are drains in and around the site. There is one drain which runs through the centre of the site, flowing south west. The second drain runs around the north of the site, flowing south to meet the first. These drains are ephemeral and dry up during periods of dry weather.

From mapping available, a surface water drain used to flow through the centre of Unit 1009. This was blocked upstream by Wormtech, with the water being diverted into the drain running along the north side of Unit 1009. This resulted in the flow ending up in the same location but reduced potential for leachate from green and food waste stored at the site to run into the drain. The drainage channel has since been backfilled.

The Castrogi brook is located west of the site. The drainage from the training facility eventually drains into this brook, which becomes the Neddem Brook further downstream. It is assumed that all surface water, if unimpeded, will eventually flow to the Severn Estuary. Surface water runoff from the Unit 1009 flows west along the drainage ditch along the southern boundary of the site and then south to a culvert beneath agricultural land on the western side of the MoD base. This culvert discharges into the Castrogi Brook.

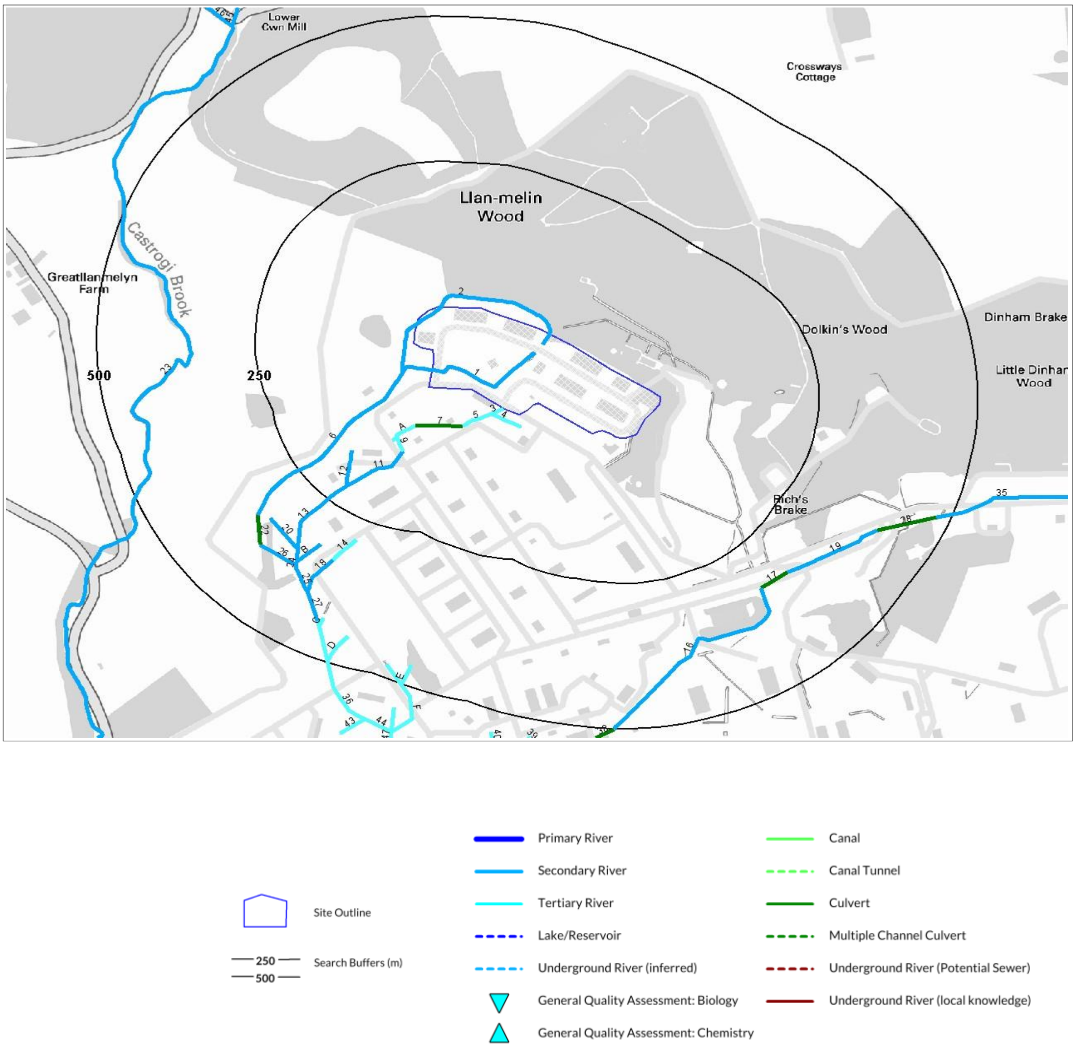


FIGURE 13: SURFACE WATER BODIES AROUND SITE

There are no surface water extractions within close proximity of the site. There is one extraction 1585m north of the site, which is upstream and therefor irrelevant to this study.

Previous Site Studies

<u>Land Quality Assessment Report – SKM Enviros – April 2014:</u>

SKM Enviros undertook a comprehensive Land Quality Assessment in April 2014. This study was subsequent to the removal of the Wormtech food waste and much of the green waste from within and around Unit 1009, by the Welsh Government. TheLQA2 report focussed on the impact of leachate from the green waste stockpiles on surface and groundwater and the residual risk to surface and groundwater from the remaining materials on site, subsequent to this removal. The study undertook a Tier 1 risk assessment with regards to this leachate, identifying the risks posed by the contamination to ground and surface waters, within Unit 1009 and the western section of the MoD Base.

The report identified localised but significant breaches of Environmental Quality Standards (EQS)/Drinking Water Standards (DWS) for leachable waste compounds, namely ammonia, manganese, BOD and iron. These exceedances were localised to the site, with no contamination being detected in wells down-gradient of the site, or within the Castrogi brook. This suggests that the contaminants are either static within the aquifer, dispersing slowly or diluted or filtered from the groundwater as it flows down-gradient. Or a combination of all of these mechanisms.

The risk assessment concluded that the risk to the groundwater local to the site is high due to the scale of contamination present within the samples taken within the site boundary. This contamination was predominantly manganese, with a lower level of contamination from ammonia. However, the report also concluded that the risk to the regional aquifer was low. This was due to the lack of contamination detected downgradient of the site boundary.

Prior to this report, SKME had undertaken 5 studies of the condition of the land at the site:

- Land Quality Assessment Desk Study (2006): This was a study into the potential for contamination as a result of effluent storage during military use. It concluded that there was very limited potential for historical contaminants at the site due to the length of time since the site was last used for this purpose;
- Environmental Assessment of Wormtech Site Facilities (2012): This was an on-site inspection of the Wormtech site, which concluded that a phased site investigation was required;
- Report on Intrusive Site Investigation Comprising Shallow Boreholes (2010): This study focused on the shallow boreholes which were installed on site. No aquifer was found, so it recommended that deeper boreholes be installed;
- Survey of Drainage Ditches South of the Wormtech Area (2012): This study was undertaken after sewage fungus was discovered in the drainage ditches south of the site. It was subsequently discovered that the composition of the waste was very similar to the water from the Wormtech leachate lagoon. As a result, the lagoon was pumped and the contents taken off site;
- Report on the Investigation of Groundwater Quality in the Limestone Aquifer (2010): This study was to determine whether the groundwater was being contaminated by the Wormtech facility. At the time, no contamination was detected within the groundwater in either boreholes.

DTE Caerwent: Former Wormtech Area LQA2 Addendum – Jacobs – July 2016:

The report was produced following a walkover site visit on the 12th – 14th April 2016. During this walkover, surface water samples were taken at 6 locations and attempted at another 2, where it was not possible to obtain a sample as the watercourse was dry.

Groundwater samples were taken from 10 boreholes, one of which is described as being up-gradient but from a review of the BH depth and with consideration of the topography of the site EcoVigour believes that this would not be significantly up-gradient.

Summary of Surface Water and Groundwater Sampling Locations

Location	Description
Surface Water Sampling Locations	
*SW202	New shallow sediment settlement pond within CTL site.
SW101	Onsite drainage ditch immediately southwest of FWA.
SW105	Onsite drainage ditch down-gradient of the FWA.
*SW201	New surface water monitoring location (onsite drainage ditch) near Building 715, situated between SW105 and SW102.
SW102	Onsite drainage ditch, SW part of MOD Caerwent at perimeter fence.
Field Culvert	Entrant to Cas Troggy culvert from field outside MOD Caerwent's SE boundary fence
SW103	On Cas Troggy brook, upstream of culvert entry.
SW104	On Cas Troggy brook, downstream of culvert entry.
Groundwater sampling locations	
BH103	Up-gradient borehole on northern edge of FWA close to building 845.
BH102	Southern edge of FWA
BH7	Southern edge of FWA
BH104	South-eastern edge of FWA.
BH105	South-western edge of FWA
BH105A	South-western edge of FWA (shallow borehole adjacent to BH105)
BH106	Down-gradient borehole on MOD Caerwent southern boundary
BH106A	Down-gradient borehole on MOD Caerwent southern boundary (shallow borehole adjacent to BH130)
BH107	Down-gradient borehole between FWA and MOD Caerwent southern boundary
BH130	Down-gradient borehole on MOD Caerwent southern boundary

Notes: * represents new surface water sampling locations.

Water quality parameters recorded for surface waters at MOD Caerwent generally revealed high electrical conductivity (EC) values, elevated temperatures and reduced dissolved oxygen (DO) at the monitoring points within the Former Wormtech Area (FAW). Together with the laboratory analysis results, which showed contaminant concentrations (biological oxygen demand (BOD), chemical oxygen demand (COD), ammoniacal nitrogen, copper, iron, mercury and manganese) in excess of Environmental Quality Standards (EQS) at locations in the Former Wormtech Area, is clear evidence of leachate contamination from the green wastes.

Contaminant concentrations reduced with distance from the FWA and no EQS exceedances were recorded in the sample from SW201 which was the furthest down-stream sample between the FWA and the Cas Troggy. It is therefore possible, although not certain, that even were increased rainfall to create a connected flow to the Cas Troggy from the FWA, that flows into the Cas Troggy may not exceed EQS.

Groundwater monitoring also recorded high EC and low DO values at boreholes located nearest to the Former Wormtech Area (FWA) (BH7 and BH102). Water quality parameters improved with distance from the FWA. Concentrations of ammoniacal nitrogen, manganese and iron recorded the greatest values and exceeded their respective EQS and/or drinking water standards (DWS) at boreholes located at the FWA and within its immediate vicinity. This suggests that leachate from the FWA is percolating into groundwaters. Copper and mercury have been detected in groundwater marginally above their EQS down-gradient of the FWA, mercury was also detected marginally above EQS in BH105 close to the FWA, but these are not considered significant.

Manganese and iron concentrations were recorded above EQS and DWS in several boreholes including those in the FWA. Unusually, concentrations of the metals in groundwater were higher than those measured in the surface water locations SW101 and SW202 which were clearly affected by leachate. This is suggestive of a contributing source of metal contamination other than the green wastes, most probably natural background mineralisation.

Monitoring in groundwater wells has shown the key leachate indicator compound, ammoniacal nitrogen is present at a concentration 9 times EQS and 7 times DWS in the well nearest the waste mounds in the FWA. Metal concentrations are also elevated in wells nearest the waste mounds but there is evidence that the metal contamination derives partly from the background geology.

Within the report, Jacobs make the following observations regarding the Unit 1009 site:

'Since Crownhill Topsoil Ltd (CTL) (note, Crownhill Topsoil is not a Limited Company) has taken over site management at the FWA within MOD Caerwent, the site appears organised and with no obvious housekeeping issues. The green waste mounds have been re-profiled to create room for CTL's activities including processing the green wastes. The roads in the FWA previously discoloured with wastes, soil and leachate residues are now largely clear; though leachate continues to be generated by the green wastes.

CTL has conducted recovery trials on the green wastes and has derived topsoils from the wastes without blending with other soils. Jacobs has observed very small quantities of plastics in the finished topsoil but CTL has stated that the materials have been tested and comply with BS3882 (2015): Specification for Topsoil. BS3882 allows for up to 0.5% deleterious material content in topsoil and the materials may therefore be compliant, however no validation testing has been undertaken as part of this study.'

DTE Caerwent: Former Wormtech Area LQA2 Addendum – Jacobs – November 2019:

A walkover survey including monitoring of surface water monitoring points and bore holes in February 2019. During the round, there was no flow from the on-site drainage ditches within or leading from the FWA. One surface water sample was collected from the attenuation pond within the FWA, however a modest flow was noted in the Cas Troggy.

Exceedances of EQS were not reported for the surface water sample. Further, no EQS exceedances were identified in the Cas Troggy brook.

Five of the twelve monitoring wells were unavailable for sampling during the February 2019 visit. Wells were either damaged (BH111, BH102 and BH7) or dry (BH103 and BH106A). Neither of the upgradient groundwater sampling locations (BH111 and BH103) were able to be sampled, and as such there is no indication of the groundwater quality prior to its passing through the site. None of the groundwater samples exceeded EQS for leachate indicator compounds or metallic contaminants. However, DWS was slightly exceeded for ammoniacal nitrogen in all boreholes, including those down-gradient of the FWA. In general, concentrations of leachate indicator compounds had remained similar to 2017 results, but had slightly increased in BH104 within the FWA.

Monitoring Locations for February 2019 Monitoring Round:

Location (*dry)	Description
Surface Water Sampling Locations	
SW201*	Onsite drainage ditch near Building 715, down-gradient of the FWA.
SW202	Lined shallow attenuation pond within the CTL site.
SW203*	Onsite drainage ditch immediately down-gradient of the FWA.
SW101*	Onsite drainage ditch immediately southwest of FWA.
SW102*	Onsite drainage ditch, SW extent of DTE Caerwent at perimeter fence.
SW103	On Cas Troggy brook, upstream of culvert entry.
SW104	On Cas Troggy brook, downstream of culvert, prior to it becoming Nedern Brook.
SW105*	Onsite drainage ditch down-gradient of the FWA.
Field Drain*	Downstream of SW102, outside DTE Caerwent's SE boundary fence.
Field Culvert*	Entrant to Cas Troggy culvert from field outside DTE Caerwent's SE boundary fence.
Groundwater Sampling locations	
BH111[#]	Up-gradient borehole to the NE of the FWA, near perimeter fence.
BH103*[###]	Up-gradient borehole on northern edge of FWA close to Building 845.
BH101	NW extent of FWA.
BH102[##]	Southern extent of FWA.
BH7[#]	Southern extent of FWA.
BH104	SE extent of FWA.
BH105	SW extent of FWA.
BH105A	SW extent of FWA (shallow borehole adjacent to BH130).
BH106	Down-gradient borehole on DTE Caerwent S boundary.
BH106A*	Down-gradient borehole on DTE Caerwent S boundary (shallow borehole adjacent to BH130).
BH107	Down-gradient borehole between FWA and DTE Caerwent S boundary.
BH130	Down-gradient borehole on DTE Caerwent S boundary.

[#] well damaged; could not be sampled

[##] well missing

[###] BH103 was not servicable during the 2017 monitoring round

The following observations were made by Jacobs during the February 2019 walkover:
'The February 2019 walkover survey confirmed that the volumes of green waste were little changed since the previous walkover survey undertaken in 2017. The green waste is located

in the same part of the site and forms two mounds, as observed in 2017. CTL confirmed that no measures to limit rainfall percolation through the stockpiles have been employed, such as sheeting or sealing of the surfaces. As such, minor amounts of leachate were observed at the base of the waste. There was no evidence of algal build-up which was observed during the 2016 visit. There was no evidence of leachate on the roads within the FWA, or pooling at the base of stockpiles. It should be noted that the survey took place during and following a sustained period of dry weather.

There were no obvious signs of changes to the size or height of the green waste stockpiles noted since the previous walkover visit in 2017. Jacobs was informed that there is no ongoing processing of the green waste, and CTL has no plans for its disposal or movement.

There appears to be a significantly lower volume of waste and aggregate stored at the CTL site in general, attributed to the revocation of the EP resulting in cessation of CTL's onsite material processing. One stockpile of processed topsoil was observed in Building 1008, which is noted to pre-date the EP revocation and is currently being sold.

Improvements were observed to drainage at the site since 2017, with the creation of attenuation ponds and existing drainage channels cleared of waste and vegetation. Runoff is now directed into these channels rather than allowed to freely drain across the site. The efficiency of this could not be assessed due to the dry weather preceding the visit. A small lined attenuation pond (20m x 4m) to the west of the site entrance is serviced by a land drain and manages runoff in this portion of the site. There was insufficient water at this location to retrieve a sample, although in future visits this location should be considered for additional surface water sampling.

Improvements to housekeeping within the FWA since 2017, were observed during the recent walkover. However, whilst roads were clear and wastes and aggregates separated, it should be noted that due to the revocation of the EP, site activity is more limited than that observed in 2017 i.e. no ongoing crushing or screening activities are currently undertaken at the site. The volume of material observed on site was low, and only one skip containing waste was present. The baled woodchip photographed on site in 2017 has been removed from the site.

Observations along the Drainage Pathways South of the Former Wormtech Area

The drainage ditch within and extending south west of the FWA was dry at the time of the site walkover, and samples could not be collected from monitoring points SW101 and SW203 (Plates 14 & 17). SW202 located within the FWA is now a lined attenuation pond and was sampled at its eastern corner.

Downstream of the FWA, drainage ditches within the central area of DTE Caerwent were all dry and monitoring points could not be sampled (SW105, SW201 and SW102). These ditches meet the drains connected to the FWA, approximately 340 m north-north-east of SW102. Inspection of these drainage ditches found them all to be dry and as a result there was no flow observed into the Cas Troggy brook from DTE Caerwent.

The Cas Troggy brook (SW103 and SW104) had a moderate flow, with low suspended sediments and an absence of odour, sheen or foam noted at both sampling locations.'

The Jacobs report states the following regarding the results of surface and groundwater monitoring:

'Groundwater pH was broadly neutral in all samples across the site. Temperature was highest within the FWA, in BH101, BH104 and BH105. This is potentially indicative of breakdown of organic materials within leachate.

EC values varied widely across the site with the highest recorded values within the FWA (BH101 and BH104 in particular). There is a clear trend of EC values decreasing with distance down-gradient of the FWA. This may be indicative of leachate percolation within the immediate vicinity of the FWA. However, the potential effect and presence of any leachate within the groundwater appears to be declining the greater the distance from the FWA.

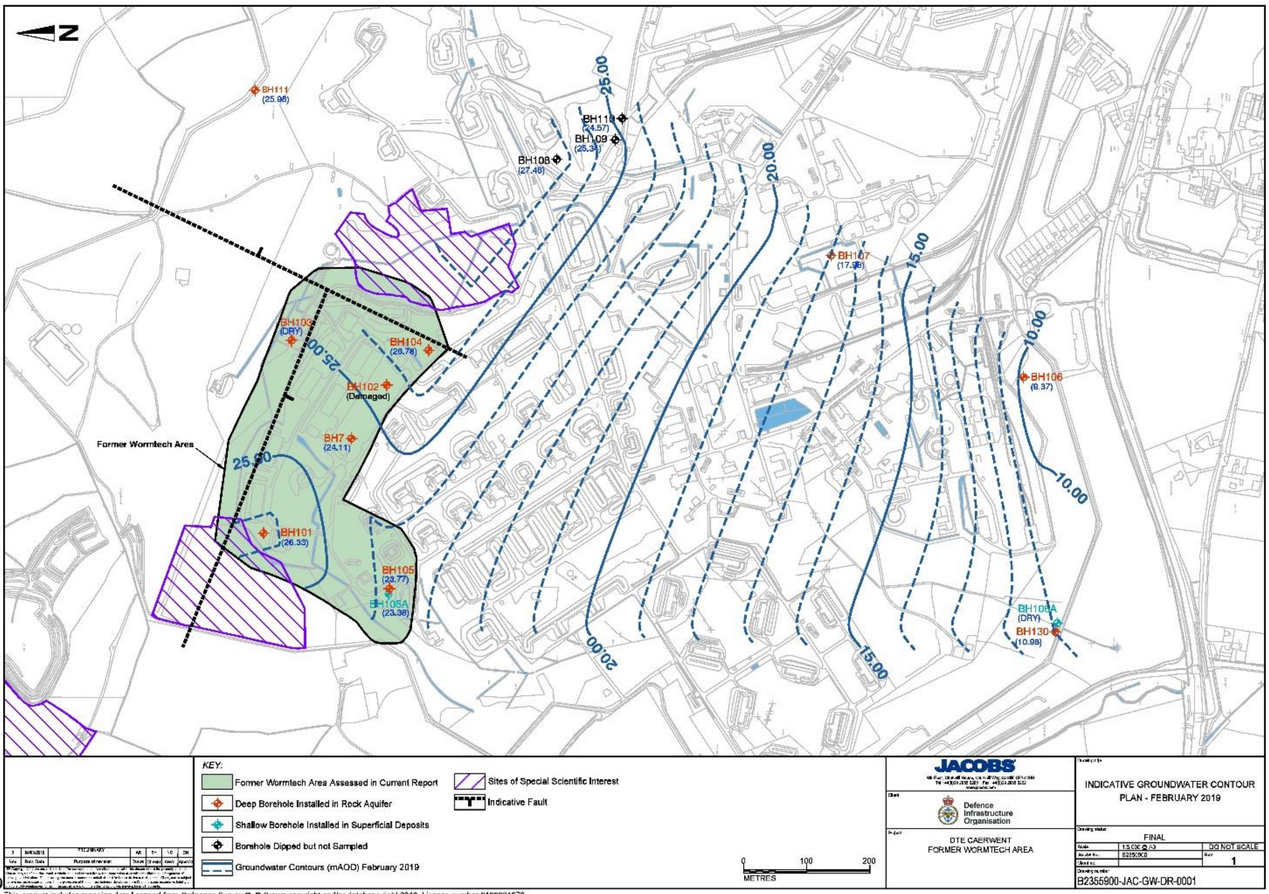
Redox potential was generally consistent across the site, between 74 – 91 mV and indicates a low positive oxidizing environment.

DO concentration is reasonable for groundwater samples, with the exception of BH104 and BH101. This is consistent with high EC in these samples and is suggestive of possible leachate contamination.

TDS concentrations in groundwater samples were all below 0.83 ppt, with highest concentrations observed in boreholes within the FWA.

An indicative groundwater contour plan has been produced based on groundwater levels recorded during the 2019 monitoring round. The indicative plan shows groundwater flowing in a southerly direction across the FWA and DTE Caerwent. It should be noted that due to the limited number of monitoring locations, this direction of flow remains indicative based upon dipped groundwater levels.

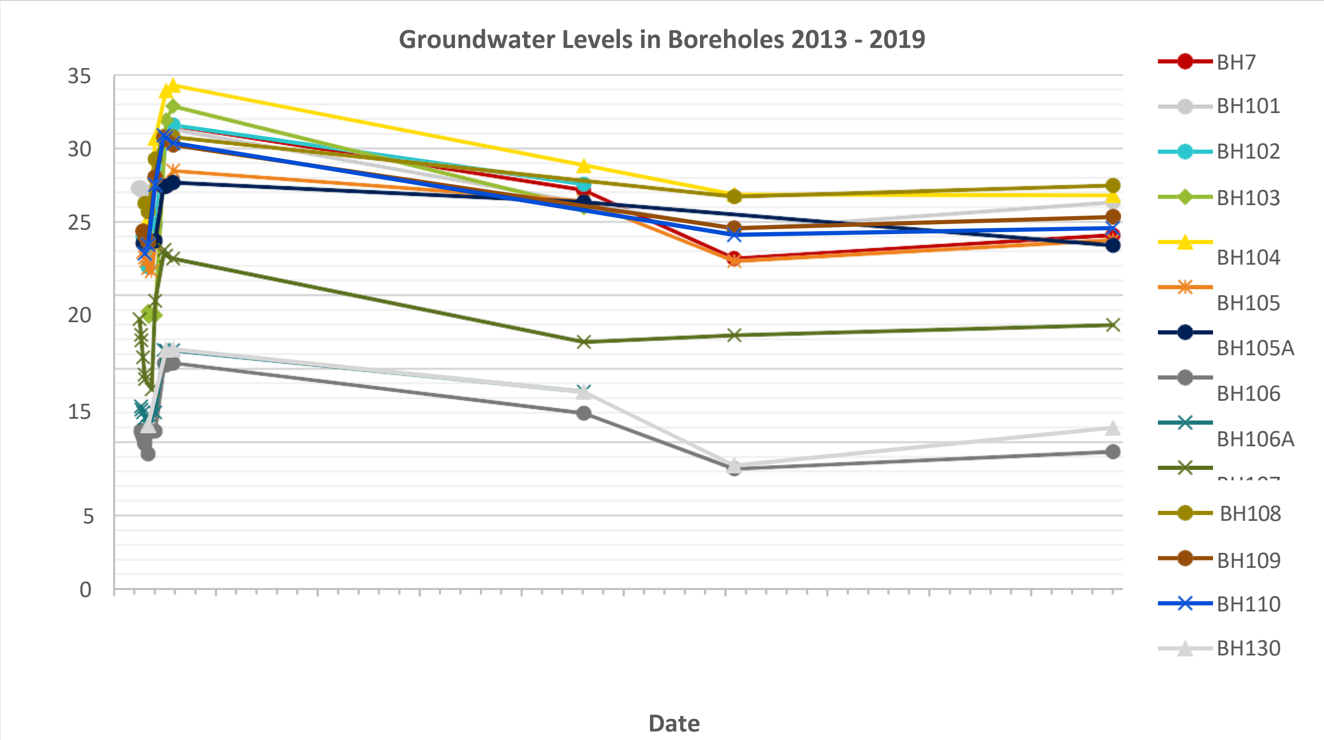
Indicative Groundwater Contours, BH Locations and Indicative Locations of Geological Faults



This product includes mapping data licensed from Ordnance Survey ®. © Crown copyright and/or database right 2019. Licence number 0100031673

The figure below, shows changes in groundwater heights between the 2013 and 2014 LQA monitoring period and 2016 – 2019 monitoring rounds. The maxima and minima groundwater heights are provided in Table 4.4. BH108 to BH110 are located on the central landfill area, outside of the FWA monitoring zone and have been included to provide information on groundwater depth. This information indicates that groundwater levels during 2019 monitoring are at or just above their lowest recorded height. The levels recorded in BH104 and BH107 were significantly above minimum vales for the period 2013 – 2017, but still below historical maxima. Existing groundwater levels are attributed to the dry winter 2018 – 2019 season preceding the recent monitoring.

Changes in Groundwater Heights between 2013 and 2019:



Conceptual Site Model

The initial conceptual site model was created to assess the risk that the site poses prior to any additional mitigation being undertaken at the site.

Potential Sources of Contamination

Assessment of the present condition of the site and its activities was undertaken through several site visits by Jacobs and EcoVigour between 2014 and 2020. These assessments highlighted four potential sources of contamination which may affect surface and groundwater conditions locally, and potentially on a regional scale:

Runoff from inert waste

The site is to be used for the storage and processing of inert construction and demolition wastes. Wastes will be admitted to the site using a strict acceptance criteria procedure. Crownhill would suffer large financial and reputational damage if contaminated materials were to enter their feedstock and subsequently be present within their finished products.

The acceptance criteria process is set out within the Crownhill Topsoil and Aggregates Environmental Management System. This states:

'The site will only be permitted to accept inert waste i.e. wastes which do not contain organic materials or liquids. The storage of non-inert wastes can result in the generation of leachate which could impact the underlying aquifer. Most of the raw materials for the process are construction and demolition wastes and excavated soils sourced through construction works. A key control in the process is a duty of care check on the site from which wastes are received. This includes a site inspection for indicators of contamination, a review of any ground investigations undertaken for the site and additional ground investigation, sampling and testing if required.

Results from ground investigations will be screened against Waste Acceptance Criteria Limit Values for Inert Waste Landfill.

Samples of produced topsoil are taken at a rate of 1 sample per 1000t produced. Samples are submitted to a UKAS accredited laboratory and tested against a suite of determinands as described in BS5228, this includes, testing for:

- particle size analysis;
- stone content (2-20mm, 20-50mm, >50mm);
- pH and electrical conductivity values;
- exchangeable sodium percentage;
- major plant nutrients (N, P, K, Mg);
- organic matter content;
- C:N ratio;
- heavy metals (As, B, Ba, Be, Cd, Cr, Cu, Pb, Hg, Ni, Se, V, Zn);
- total cyanide and total (mono) phenols;
- speciated PAHs (US EPA16 suite);
- aromatic and aliphatic TPH (C5-C35 banding);
- benzene, toluene, ethylbenzene, xylene (BTEX);
- asbestos screen

The following is a section for the Crownhill EMS:

'If indicators of contaminated materials are discovered (odours, discolouration, sheens on water, bubbling, hazardous waste items) within soils and aggregates received at the site, they will be rejected immediately and returned to the supplier. If it is not possible to immediately return these to the consignee (if transport needs to be arranged etc), wastes will be removed to the quarantine area in Building 1. As the wastes are within a building, rainwater will not be able to percolate through them and drainage from the building can be isolated into a tank, which would be emptied by tanker (following suitable sampling and testing, with determinands derived based on the nature of the waste, to enable the liquid waste to be accurately described)

Training will be provided for personnel in the recognition of the indicators of contaminated material and actions to be taken on discovery'.

Inert materials at the site can be separated into two categories, feedstock and product. Feedstock will be comprised of soils, rock, concrete, brick and ceramics. These are segregated into types for processing into products for sale. Feedstocks are then crushed and screened using the required ratio to achieve the required product. Products include:

Topsoil, which will contain a majority of fines from soils. This material is moisture critical and is stored in Building 5;

Sub-base materials, which will include some fine but predominantly granular materials;

Granular materials of varying grades.

There is potential that soils could be admitted onto site, which contain pockets of contaminated material, which over time could leach to the environment. Due to the duty of care process and the acceptance criteria, significant volumes of contaminated materials would not be accepted onto site or would be identified on being tipped and either removed immediately or quarantined for removal as soon as possible. The potential for pockets of contamination to leach will depend on a number of factors, including the bioavailability of the elements / compounds within the soils, the physical composition of the materials i.e. clays are more likely to lock up contaminants. Due to the low likelihood of significant volumes of contaminated materials being imported, in consideration of the overall volumes of materials on site, the risk of this being a significant source is low.

Inert wastes are stored predominantly on concrete surfaced areas but also on stone surfaced areas. Runoff from wastes stored on concrete surfaced areas, flows along the kerb line into attenuation ponds. Attenuation ponds are lined and have been constructed to remove suspended solids prior to discharge of the site runoff into the drain flowing along the southern boundary. Discharge from the ponds will be via a full retention hydrocarbon separator.

The risk of leachate from inert wastes is therefore considered to be low.

Fire Water

As all wastes stored on site are inert, there is no risk of combustion within waste materials.

Volumes of water likely to be used for fire fighting are difficult to predict as this depends on a number of factors, including the nature and extent of the fire.

A Fire Prevention Plan has been produced by Crownhill and this states the following:

‘The area of the site with the highest risk of fire is the workshop and adjacent site waste storage area. All other materials stored within the site are inert. If fire were to occur within this area it would most likely be due to vehicle fire or the combustion of stored oils within the workshop. From discussions with South Wales Fire and Rescue, these sorts of fires would be tackled using foam or if small scale CO_2.

If water is required for firefighting it will be abstracted from the attenuation ponds and the duck pond, this water will be recirculated back into the attenuation ponds. The outlet from the hydrocarbon separator would be shut off to prevent water leaving site. South Wales Fire and Rescue have told us that as part of their standard practice they deploy water filled booms to channel water away from sensitive receptors. A stock of sand bags will be stored at the site and these will be used to direct firewater.

If required, water flowing into the attenuation ponds could be recirculated, either at the outlet of the ponds so that suspended solids are removed or upstream of the pond.

An additional pond to retain firewater can be formed within the soil storage area. A 14m x 30m HDPE liner will be retained at the site as part of the firefighting inventory. A pond can be formed using plant on site and can be lined with the HDPE sheet. Firefighting water can then be diverted into here, through the construction of a drain and can be retained. This would provide an additional capacity of 275,000l of storage.

Water from this and other attenuation ponds will be tankered to the mains sewer if additional capacity is required.

Provision would need to be made to remove solids from the ponds, test this material and dispose of it within the Duty of Care for the material, following the fire.’

Hydrocarbon Leaks and Spills

Diesel is used for all plant on site. This is kept in a double-skinned tank within the workshop. Plant is refuelled only in this location, where a plant nappy is used to prevent spillages. Due to this, the risk of spillage of hydrocarbons is low.

Crownhill operates a fleet of haulage wagons, most of these are under 5 years old. Crownhill also operates plant at the site, some of this is under 5 years old and some of it is older. Once the site is operational, third party vehicles will enter the site. There is potential for these vehicles / plant to leak diffuse amounts of hydrocarbons or bulk hydrocarbons (0.5l to 5l) due to mechanical failure such as burst hydraulic hoses.

There is a spill response procedure in the EMS and spill kits and spill response equipment will be maintained on site.

Hydrocarbons should be considered as a possible source of contamination at site.

Silt from Inert Soil and Stone

There are large stockpiles of inert soil and stone which, as part of the site activity, is periodically screened and crushed to create a sellable product. Much of the material is stored within the covered sheds on site, however some of the material is stockpiled in the open on hardstanding. During periods of intense rainfall, surface runoff from these stockpiles can become contaminated with silt. In areas of the site which are stone surfaced, this will percolate into the ground. It is unlikely that silt would progress further than the upper layers of soil before it was filtered out.

Silt will be transported by site runoff into surface water, unless controls are put in place to prevent this.

Legacy Wastes from the Wormtech Facility:

These are not considered as a source as part of the operation of the Crownhill Topsoil and Aggregates facility but these wastes now lie just outside the boundary of the site. From surface and groundwater monitoring undertaken at Unit 1009, designated as the Former Wormtech Area (FWA) the results indicate that contamination was initially localised but that this spread a little further into the underlying shallow aquifer, over time but that contamination levels have reduced with time.

Some of the green wastes from the operation of the FWA are stockpiled adjacent to the site boundary. This has matured to a more stable form and from visual assessments, leachate emitted from the materials appears to be reducing i.e. leachate with algal blooms has not recently been noted at the site.

As part of these studies Jacobs have recommended that the wastes are covered to prevent the ingress of rainwater. They have suggested that initially, this is achieved by covering the wastes with plastic sheeting. We however have concerns about this, as there is potential for green wastes / compost to become anaerobic, which will exacerbate leaching potential. Crownhill do not want to include this material within their feedstock for their soil making process due to the complexity this brings to their Environmental Permit application due to the underlying SPZ1.

Dialogue should be established between the MoD/DOI, Natural Resources Wales and Crownhill to gain an understanding of each organisations aspirations for the management of these materials and how this can be incorporated into the operation of the site.

Pathways

Three potential pathways have been identified which would allow contaminants to enter surface water bodies or groundwater:

Surface Water Run-off

If the source material is subjected to water, surface runoff may occur, freeing suspended solids and potentially hydrocarbons from their source and channelling it through the drainage systems present on site. Site drainage discharges to open drainage channels which eventually discharge into the Castrogi Brook.

Leaching to Groundwater

Leaching to groundwater is the most likely to occur for material kept in the open. Rainwater will percolate through the source material and into the soil, where it will continue through the superficial deposits and into the aquifers within the bedrock.

Previous studies have found that the recharge at the site is dominated by dispersed recharge from incident rainfall across the site, rather than fast recharge and discharge associated with fast moving, highly permeable geology. This can be seen in Figure 12, where there are no significant peaks or troughs.

Jacobs have determined that there is a geological fault running north to south across the very eastern side of the site, which has potential to form an increased pathway for liquids from the surface into the underlying shallow aquifer.

The Castrogi brook, which runs adjacent to the site's western boundary, may be considered an area of concentrated recharge. This likely accepts some of the rain water from the site, although site drainage has been designed to channel the runoff from the problematic areas away from this.

Groundwater Migration

The movement of the groundwater via aquifer is a significant transport mechanism for potential contaminants. The SKM report identifies the flow of the groundwater to be via fractures/fissures. However, it does point out that there is no indication of large, well developed conduits, nor is there indication of large solutional developments. Borehole data suggests that the aquifer below the Caerwent training site is moderately heterogenous in nature, even though connectivity across the Crownhill site is limited.

Receptors

The identified receptors for contaminated ground and surface water are listed below:

Groundwater on Site

The ground water below the site forms part of the Source Protection Zone 1 for the Severn Tunnel Great Spring abstraction, and as such should be considered to be of significant importance. Although there are no abstraction points on site, the groundwater may discharge into streams to the south of the site, such as Neddem Brook.

Groundwater off Site

There are 4 abstraction locations which have been identified down gradient of the site. These are:

- Phillips Abstraction;
- Broome & Co Ltd Abstraction;
- Marriott St Pierre Hotel & Country Club Abstraction;
- Severn Tunnel Great Spring Abstraction.

The most significant of these is the Severn Tunnel Great Spring Abstraction, which is located 6km SE of the Crownhill site. This is used for drinking water.

Surface Water

There are a number of small drainage ditches across the Caerwent Army Training facility. These generally feed into the Castrogi brook to the west of the site. This stream becomes the Nedern brook south of the Army training site.

The Dinham Meadows SSSI has not been considered a receptor as it is situated up gradient of the site.

The Nedern Wetlands SSSI can be considered a minor receptor. Although some of the groundwater or surface water from the site may eventually end up at the Wetlands, it is located 2km downstream, and as such is unlikely to be affected by discharge from the site.

Risk Assessment

The risk assessment for this study has been carried out in two stages. Firstly, the initial assessment is undertaken on the site prior to any mitigation measures being in place. Should the risk identified be unacceptable, mitigation methods will be proposed, and the risk assessment repeated.

Compliance Points

The identification of compliance points is key in ensuring that the site can be monitored for potential contamination on identified receptors. They must be representative of the site discharge, so location is key. It is also vital that the correct assessment criteria be used to assign the maximum acceptable values for each potential contaminant.

Groundwater On Site

Borehole BH7 has been chosen as the Compliance Point for on-site groundwater monitoring. This is due to the fact that in previous investigations relating to the former Wormtech operations at the site, this borehole had the most exceedances of EQS and DWS. This suggests that this borehole is in an area of aquifer, which receives surface runoff from the site percolating into the aquifer. The borehole is also downgradient of site activities.

Groundwater Off Site

BH102 (once this has been reinstated) BH104, BH105 will be monitored every six months. From groundwater levels measures during the Jacobs April 2019 round of monitoring it appears that groundwater flow immediately below the site is to the SW and hence BH105 is proposed as the off site compliance point. As these groundwater contours have been developed from limited level information, BH104 will also be included.

This BH will be purged and sampled every six months. Purging will continue until compliance monitoring undertaken at the borehole stabilises and becomes consistent. Samples will then be taken and submitted to a UKAS accredited laboratory for analysis against the following parameters:

pH, EC, BOD, COD, Choride, Ammonia, Ammoniacal Nitrogen, Arsenic, Boron, Cadmium, Chromium, Copper (dissolved and bioavailable), Iron, Mercury, Manganese (dissolved and bioavailable), Nickel (dissolved and bioavailable), Lead (dissolved and bioavailable), Zinc (dissolved and bioavailable), TPH (speciated), EPH (C10-C40), SS.

Environmental Quality Standards (EQS) and Drinking Water Standards (DWS) are the most appropriate standards for the assessment of lab results.

Surface Water

Crownhill will establish surface water compliance points on the drainage ditch at the SW corner of the site (CHSW001) and at the discharge point into the Castrogi Brook (CHSW002). Monitoring will be undertaken monthly at these compliance points (except for periods when there is not flow), for suspended solids, BOD ATU, electrical conductivity, TPH (speciated), and ammonia.

Further sampling will be undertaken by Crownhill, with surface water samples from CHSW001-02 submitted for analysis against the same parameters as have been used within the Jacobs LQA plus EPH (C10-C40) and PAH16.

As there are no potable water surface water abstractions within the vicinity of the site, it has been determined that Environmental Quality Standards may be utilised as Compliance Points for contaminants.

Qualitative Risk Assessment Prior to Mitigation

Source	Identified Pollutant	Identified Receptors	Pathways to Receptors	Associated Hazard	Likelihood of Occurrence	Risk/Significance
Leachate from Fire Water	Phosphates; Sulphates Nitrates; Chlorinated dioxins/furans; BTEX, PAHs; Small organic compounds (formaldehyde, acrolein, butadiene, vinyl chloride, etc.); Metals.	Groundwater on-site	Leaching, Groundwater Migration	Medium	Low	Low
		Groundwater off-site	Groundwater Migration	Medium	Low	Low
		Surface Water	Surface Runoff, Groundwater Migration	Medium	Low	Low
Spilled / Leaking Hydrocarbons	TPH, PAH	Groundwater on-site	Leaching, Groundwater Migration	High	Medium	Medium
		Groundwater off-site	Groundwater Migration	High	Medium	Medium
		Surface Water	Surface Runoff, Groundwater Migration	High	Medium	Medium
Silt Contaminated Runoff	Suspended Solids	Groundwater on-site	Leaching, Groundwater Migration	Low	Low	Low
		Groundwater off-site	Groundwater Migration	Low	Low	Low

		Surface Water	Surface Runoff, Groundwater Migration	Medium	High	High
Contaminated soils imported to site.	Potential contaminants including TPH, PAH, Metals, Organics, etc	Groundwater on Site	Leaching, Groundwater Migration	Potentially High	Medium	Medium
		Groundwater off Site	Groundwater Migration	Potentially High	Medium	Medium
		Surface Water	Surface Runoff, Groundwater Migration	Potentially High	Medium	Medium

Mitigation Methods

As High risk activities have been identified for the site, it is necessary to incorporate mitigation measures to reduce this risk level.

Fire Water

The incorporation of a strict fire prevention plan will severely reduce the risk of fire occurring. Due to the limited volume of combustible material stored on site i.e all wastes are inert hence combustible materials are those linked to the operation of the facility only, it is anticipated that volumes of fire water would also be low.

If water is required for firefighting it will be abstracted from the attenuation ponds and the duck pond, this water will be recirculated back into the attenuation ponds. The outlet from the hydrocarbon separator would be shut off to prevent water leaving site. South Wales Fire and Rescue have told us that as part of their standard practice they deploy water filled booms to channel water away from sensitive receptors. A stock of sand bags will be stored at the site and these will be used to direct firewater.

If required, water flowing into the attenuation ponds could be recirculated, either at the outlet of the ponds so that suspended solids are removed or upstream of the pond.

An additional pond to retain firewater can be formed within the soil storage area. A 14m x 30m HDPE liner will be retained at the site as part of the firefighting inventory. A pond can be formed using plant on site and can be lined with the HDPE sheet. Firefighting water can then be diverted into here, through the construction of a drain and can be retained. This would provide an additional capacity of 275,000l of storage.

Water from this and other attenuation ponds will be tankered to the mains sewer if additional capacity is required.

Provision would need to be made to remove solids from the ponds, test this material and dispose of it within the Duty of Care for the material, following the fire.'

Inert Construction and Demolition Wastes

The acceptance criteria process is set out within the Crownhill Topsoil and Aggregates Environmental Management System. This states:

'The site will only be permitted to accept inert waste i.e. wastes which do not contain organic materials or liquids. The storage of non-inert wastes can result in the generation of leachate which could impact the underlying aquifer. Most of the raw materials for the process are construction and demolition wastes and excavated soils sourced through construction works. A key control in the process is a duty of care check on the site from which wastes are received. This includes a site inspection for indicators of contamination, a review of any

ground investigations undertaken for the site and additional ground investigation, sampling and testing if required.

Results from ground investigations will be screened against Waste Acceptance Criteria Limit Values for Inert Waste Landfill.

Samples of produced topsoil are taken at a rate of 1 sample per 1000t produced. Samples are submitted to a UKAS accredited laboratory and tested against a suite of determinands as described in BS5228, this includes, testing for:

- particle size analysis;
- stone content (2-20mm, 20-50mm, >50mm);
- pH and electrical conductivity values;
- exchangeable sodium percentage;
- major plant nutrients (N, P, K, Mg);
- organic matter content;
- C:N ratio;
- heavy metals (As, B, Ba, Be, Cd, Cr, Cu, Pb, Hg, Ni, Se, V, Zn);
- total cyanide and total (mono) phenols;
- speciated PAHs (US EPA16 suite);
- aromatic and aliphatic TPH (C5-C35 banding);
- benzene, toluene, ethylbenzene, xylene (BTEX);
- asbestos screen

The following is a section for the Crownhill EMS:

'If indicators of contaminated materials are discovered (odours, discolouration, sheens on water, bubbling, hazardous waste items) within soils and aggregates received at the site, they will be rejected immediately and returned to the supplier. If it is not possible to immediately return these to the consignee (if transport needs to be arranged etc), wastes will be removed to the quarantine area in Building 1. As the wastes are within a building, rainwater will not be able to percolate through them and drainage from the building can be isolated into a tank, which would be emptied by tanker (following suitable sampling and testing, with determinands derived based on the nature of the waste, to enable the liquid waste to be accurately described)

Training will be provided for personnel in the recognition of the indicators of contaminated material and actions to be taken on discovery'.

Inert materials at the site can be separated into two categories, feedstock and product. Feedstock will be comprised of soils, rock, concrete, brick and ceramics. These are segregated into types for processing into products for sale. Feedstocks are then crushed and screened using the required ratio to achieve the required product. Products include:

Topsoil, which will contain a majority of fines from soils. This material is moisture critical and is stored in Building 5;

Sub-base materials, which will include some fine but predominantly granular materials;

Granular materials of varying grades.

There is potential that soils could be admitted onto site, which contain pockets of contaminated material, which over time could leach to the environment. Due to the duty of care process and the acceptance criteria, significant volumes of contaminated materials would not be accepted onto site or would be identified on being tipped and either removed immediately or quarantined for removal as soon as possible. The potential for pockets of contamination to leach will depend on a number of factors, including the bioavailability of the elements / compounds within the soils, the physical composition of the materials i.e. clays are more likely to lock up contaminants. Due to the low likelihood of significant volumes of contaminated materials being imported, in consideration of the overall volumes of materials on site, the risk of this being a significant source is low.

Inert wastes are stored predominantly on concrete surfaced areas but also on stone surfaced areas. Runoff from wastes stored on concrete surfaced areas, flows along the kerb line into attenuation ponds. Attenuation ponds are lined and have been constructed to remove suspended solids prior to discharge of the site runoff into the drain flowing along the southern boundary. Discharge from the ponds will be via a full retention hydrocarbon separator.

The risk of leachate from inert wastes is therefore considered to be low.

Hydrocarbons from Vehicle and Plant Movements

All fuel and oil storage is in the eastern section of the site. The majority of plant and vehicle movements will also take place in this area of the site. Therefore, surface runoff from the eastern section of the site will be discharged via a series of attenuation ponds discharging via a Full Retention Hydrocarbon Separator to remove residual hydrocarbons.

The western sector of the site, will be little used with only the buildings being used for soil storage. Therefore runoff from this area will be discharged via a series of three attenuation ponds.

Some areas of the site are surfaced with compacted stone. This has limited permeability which could result in hydrocarbons being able to enter the underlying groundwater. A robust spill response procedure will be put in place. If hydrocarbons are spilt to concrete surfaced areas, they will be contained using absorbent booms / pads / granules. Contaminated soils and aggregates will be excavated and placed into plastic lined skips within the quarantine building, awaiting disposal.

Spill kits will be maintained in the workshop and within vehicles and plant. Staff will be given training in spill control and the use of spill kits and spill response materials.

Silt Contaminated Runoff

A series of three attenuation ponds have been constructed to receive runoff from the eastern section of the site. These have a total surface area of 550m^2. These have been lined with a HPDE liner to prevent infiltration.

A series of three attenuation ponds, have been constructed to receive runoff from the western section of the site. These have a combined surface area of 550m^2 and are lined with an HDPE liner.

Both of these ponds discharge into the large drain which runs along the southern boundary of the site. This is dry for the majority of the year with only a low flow during sustained periods of heavy rainfall. There is therefore additional attenuation and infiltration capacity within this.

Revised Conceptual Model

With the mitigation measures described above in place, the conceptual model becomes significantly different. The likelihood of all risks occurring have significantly reduced.

Qualitative Risk Assessment Post Mitigation

Source	Identified Pollutant	Identified Receptors	Pathways to Receptors	Associated Hazard	Likelihood of Occurrence	Risk/Significance
Leachate from Fire Water	Phosphates; Sulphates Nitrates; Chlorinated dioxins/furans; BTEX, PAHs; Small organic compounds (formaldehyde, acrolein, butadiene, vinyl chloride, etc.); Metals.	Groundwater on-site	Leaching, Groundwater Migration	Medium	Low	Low
		Groundwater off-site	Groundwater Migration	Medium	Low	Low
		Surface Water	Surface Runoff, Groundwater Migration	Medium	Low	Low
Spilled / Leaking Hydrocarbons	TPH, PAH	Groundwater on-site	Leaching, Groundwater Migration	Medium	Low	Low
		Groundwater off-site	Groundwater Migration	Medium	Low	Low
		Surface Water	Surface Runoff, Groundwater Migration	Medium	Low	Low
Silt Contaminated Runoff	Suspended Solids	Groundwater on-site	Leaching, Groundwater Migration	Low	Low	Low
		Groundwater off-site	Groundwater Migration	Low	Low	Low
		Surface Water	Surface Runoff, Groundwater Migration	Medium	Low	Low
Contaminated soils imported to site.	Potential contaminants including TPH, PAH, Metals, Organics, etc	Groundwater on Site	Leaching, Groundwater Migration	Low	Low	Low
		Groundwater off Site	Groundwater Migration	Low	Low	Low
		Surface Water	Surface Runoff, Groundwater Migration	Low	Low	Low

Conclusions

The primary potential sources of contamination which have been identified by this report are:

- Leachate from fire water in the event of a fire at the site;
- Leachate from the spillage of hydrocarbons;
- Silt contaminated runoff from inert soil and stones;
- Leachate / runoff from contaminated / out of spec soils imported to site.

The initial risk assessment identified that the risk to local groundwater was moderate due to the storage and use of hydrocarbons on site.

The ground water is at particular risk as the bedrock below the site is a principle aquifer, forming part of the Severn Estuary Source Protection Zone.

Previous studies by SKM Enviros / Jacobs have identified that leachate from the Wormtech legacy materials stockpiles on site travels to the aquifer locally. Due to this, it can be expected that if any liquids released at the site are uncontrolled, they too have potential to enter groundwater beneath the site.

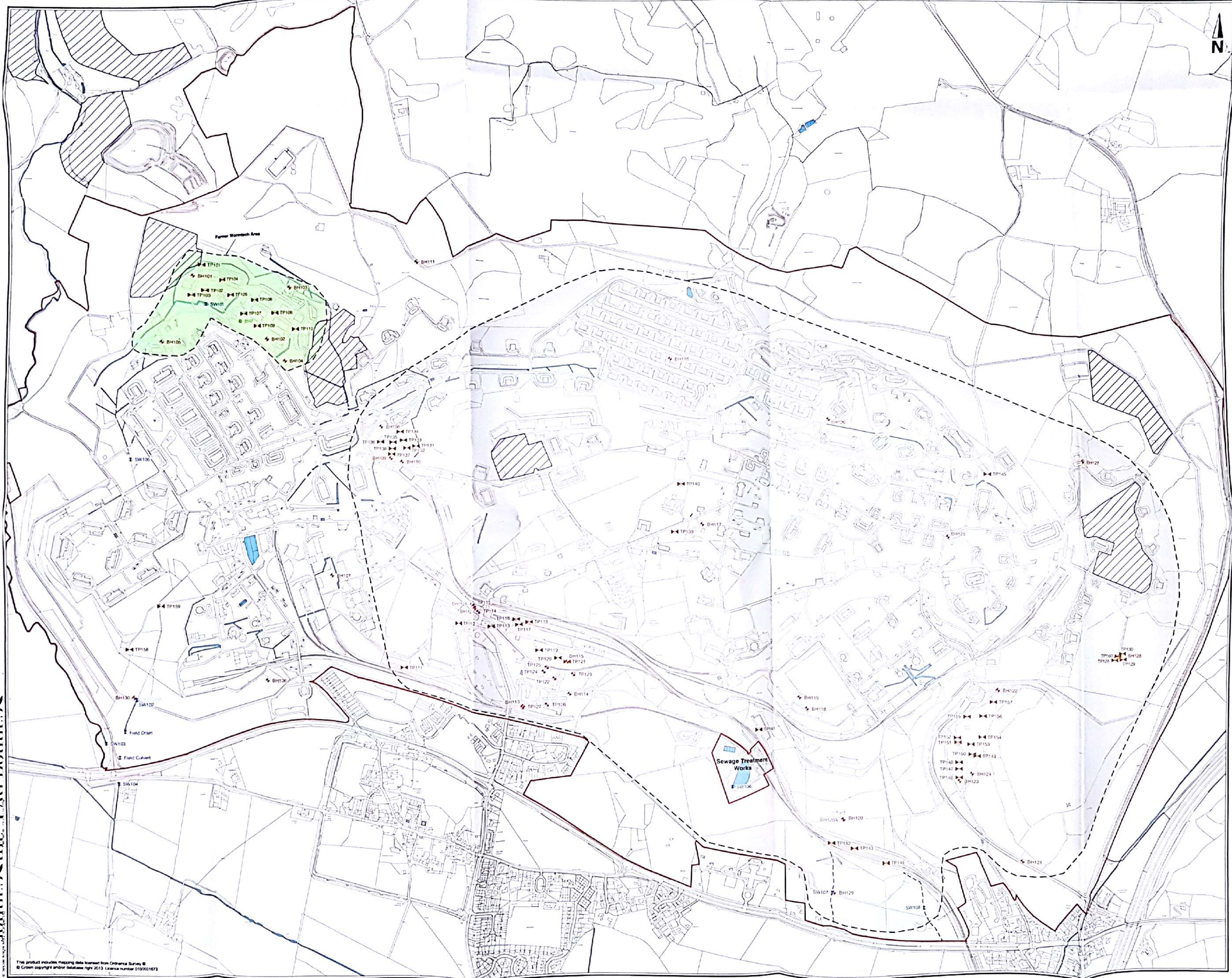
However, the study also found that the contamination of the groundwater, from the previous use of the site as a green waste facility, was local to the site, and contamination was either not identified or significantly reduced in groundwater tested further down the hydraulic gradient. This, along with the slow recharge rate of the groundwater, indicates that the time taken for water to flow off site is significant enough to allow contaminants to filter out of the aquifer or degrade within the aquifer.

Although the contamination of the regional aquifer is likely extremely limited, it is still necessary to implement mitigation measures to ensure that the local aquifer is not contaminated through site activity. This document highlights a series of measures which will be put in place which significantly reduce the likelihood of the site having an impact on this aquifer.

It was identified that the highest risk to surface water at the site is through silt contaminated runoff. However, there is some risk to this receptor from the other sources identified. Provided that the mitigation measures specified are implemented at the site, the risk to surface water and groundwater from site activities, will be reduced to an acceptable level.

It is recommended that monitoring at the compliance points identified be undertaken monthly for surface water and every six months for groundwater, as described above. Monitoring should also take place following incidents such as hydrocarbon spillage or a fire on site, which requires significant volumes of water to be used to extinguish it.

Appendix 1: Site Layout and Exploratory Hole Location Plan (Large Scale)



KEY:

- Former Wormtech Area Assessed in Current
- Exploratory Holes in This Area Not Assessme Current Report
- Rotary Boreholes with Standpipes Installed in Rock Aquifer
- Cable Percussive Boreholes with Shallow St Installation
- Cable Percussive Boreholes without Standpi
- Window Sample Borehole with Shallow Stan Installation
- Window Sample Borehole without Standpipe
- Mechanical Trial Pit Excavation
- Surface Water Monitoring Point
- Existing Standpipes in Rock Aquifer
- Seasonal Surface Water Feature
- Sites of Special Scientific Interest (SSSI)

NOTES:

REV	DESCRIPTION	DATE
Rev A		

Defence Infrastructure Organisation

DTE CAERWENT - FORMER WORMTECH AREA PHASE 2 LAND QUALITY ASSESSMENT

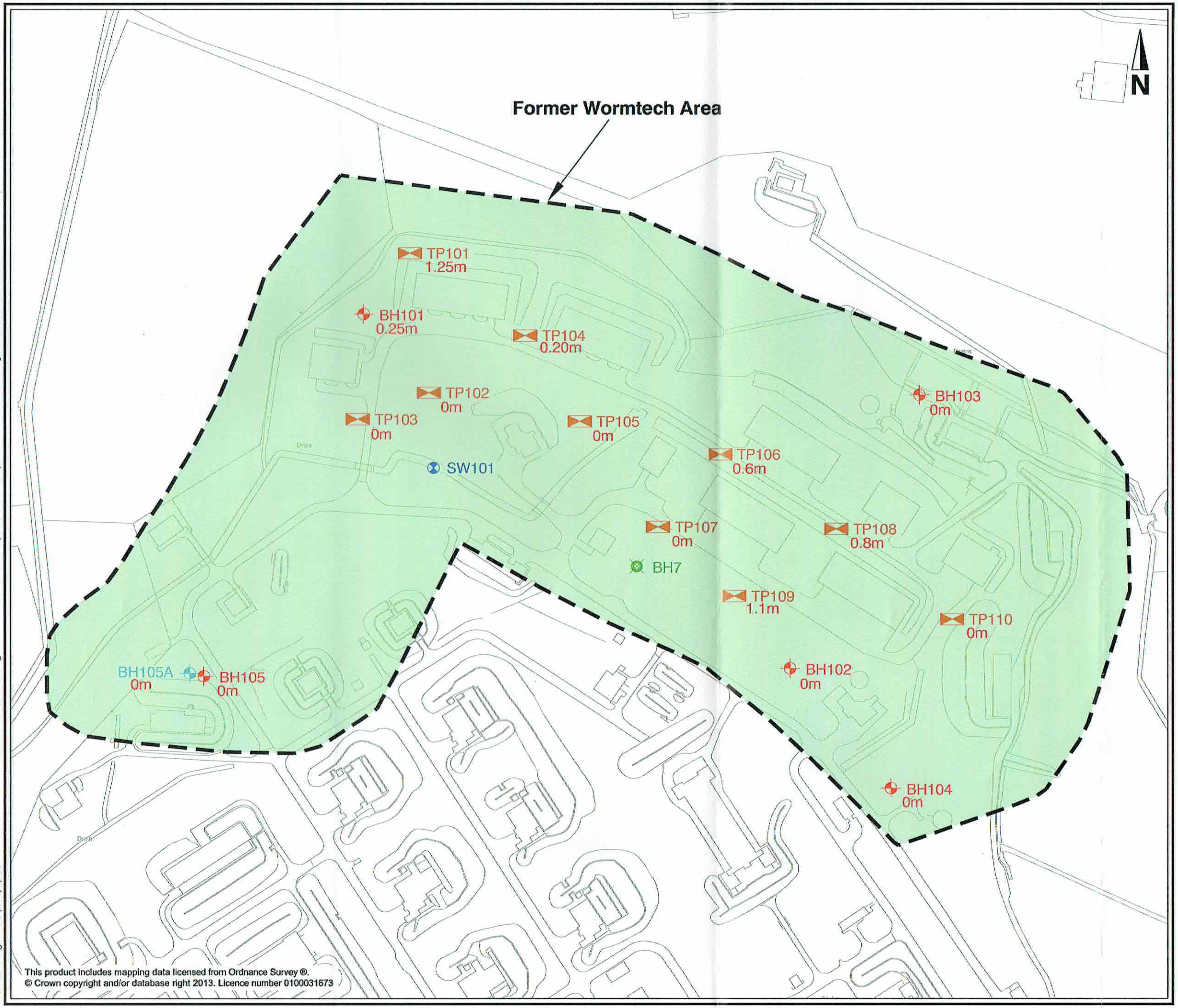
FIGURE 2

SITE LAYOUT AND EXPLORATORY HOLE LOCATION PLAN

SCALE	1:5,000 @ A1	PROJECT No.	JL3079
CONTENT	AJO	DRAWN	HLD
CHECKED	SLH	DATE	MARCH 2014

SKM ENVIROS

Appendix 2: Site Layout and Exploratory Hole Location Plan (Small Scale)



KEY:

- Mechanical Trial Pit Excavation
- Rotary Boreholes with Standpipes Installed in Rock Aquifer
- Cable Percussive Boreholes with Shallow Standpipe Installation
- Surface Water Monitoring Point
- Existing Standpipes in Rock Aquifer
- >2.2m Depth to Base of Waste

NOTE:

Waste composed of green composting waste and plastics. Contains leachable contaminants including Metals, Ammonia, Chloride, BOD and conductivity.

Rev A

REV.	*DESCRIPTION*	*DATE*

Defence Infrastructure Organisation

DTE CAERWENT -
FORMER WORMTECH AREA
PHASE 2 LAND QUALITY ASSESSMENT

FIGURE 4

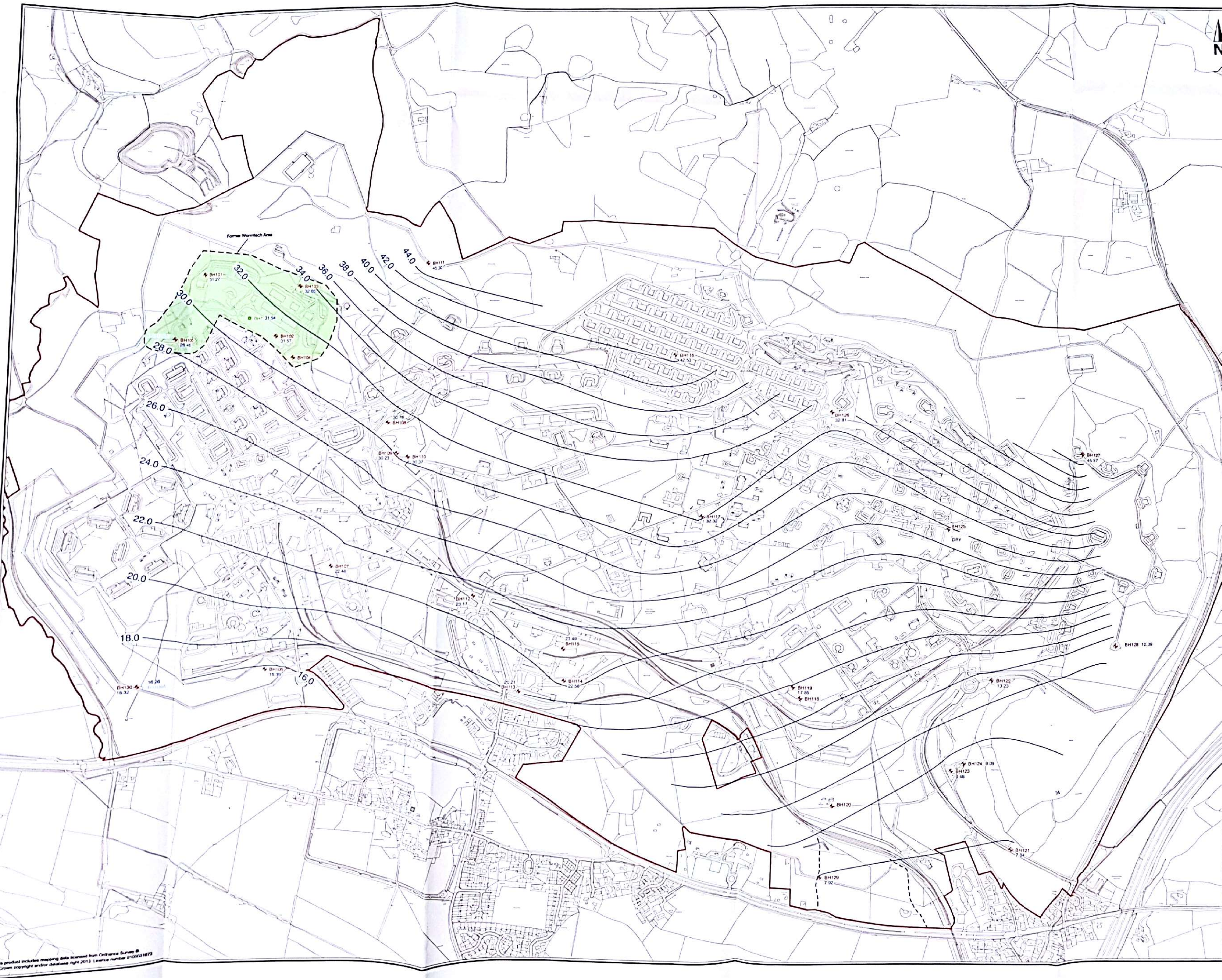
IDENTIFIED CONTAMINATION

SCALE 1:1,000 @ A3	*PROJECT No.* JL30794
CONTENT AJO	*DRAWN* HLD
CHECKED SLH	*DATE* MARCH 2014

SINCLAIR KNIGHT MERZ
SKM ENVIROS

File name: HLD4115.dwg   Plot date: Apr 15, 2014 - 4:23pm   Ref: I:\Enviros\Design\PROJECTS\JLW\JL30794\

Appendix 3: Indicative Groundwater Contour Plan



KEY:

- Rotary Boreholes with Standpipes Installed in Rock Aquifer
- Cable Percussive Boreholes with Shallow Standpipe Installation
- Existing Standpipes in Rock Aquifer
- Seasonal Surface Water Feature
- 31.28 Groundwater Height (m OD) - 27th January 2014
- Groundwater Contours (m OD)

NOTES:

Groundwater levels from boreholes with anomalous groundwater readings have been omitted from the plan. These locations are generally where water levels were very close to the base of the installation.

The aquifer at Caerwent is heterogeneous and the contour plan has been prepared to provide an indication of the flow direction and likely hydraulic gradient. Water levels can vary markedly between boreholes located close to one another and where apparent anomalies have been identified these have been excluded from the map. Anomalous locations are often where water levels are close to the base of the installation.

REV	DESCRIPTION	DATE
Rev A		

Defence Infrastructure Organisation

DTE CAERWENT -
FORMER WORMTECH AREA
PHASE 2 LAND QUALITY ASSESSMENT

FIGURE 3

INDICATIVE GROUNDWATER CONTOUR PLAN (JANUARY 2014)

SCALE	1:5,000 @ A1	PROJECT No.	JL3079[illegible]
CONTENT	AJO	DRAWN	HLE
CHECKED	SLH	DATE	MARCH 2014

SKM ENVIROS

Appendix 4: Jacobs Land Quality Assessment Report – LQA2 2016

DTE Caerwent: Former Wormtech Area LQA2 Addendum

Defence Infrastructure Organisation

Environmental Monitoring at MOD Caerwent

B41600AB/R01 | RO

14th July 2016

JACOBS

DTE Caerwent: Former Wormtech Area LQA2 Addendum

Project No:	B41600AB
Document Title:	Environmental Monitoring at DTE Caerwent
Document No.:	B41600AB/R01
Revision:	RO
Date:	14th July 2016
Client Name:	Defence Infrastructure Organisation
Client No:	DIO Project Number: 13238
Project Manager:	Anthony John
Author:	Emily Pugh
File Name:	P:\SSBU\B41600AB - Caerwent\3 - Issued Documents\R0001 - Former Wormtech Area LQA2 Addendum\B41600AB-R0001-R0 DTE Caerwent Former Wormtech Area LQA2 Addendum.docx

Jacobs U.K. Limited

Churchill House
Churchill Way
Cardiff, CF10 2HH
United Kingdom
T +44 (0)29 2035 3200
F +44 (0)29 2035 3222
www.jacobs.com

Document history and status

Revision	Date	Description	By	Review	Approved
0	14/07/2016	Environmental Monitoring Report	EP	SLH	AJ

Contents

Executive Summary

Jacobs was commissioned by Defence Infrastructure Organisation (DIO) to undertake further environmental monitoring at MOD Caerwent following the Phase 2 Land Quality Assessment (LQA) carried out by SKM Enviros (now Jacobs) in 2013 – 2014.

Aims and Scope of Works

Environmental monitoring has been carried out at the site with the aim of determining:

1. Whether the recovery of topsoils from the green wastes is being carried out by CTL is in a manner which minimises environmental impacts;
2. Any obvious flaws in the process, e.g. plastics remaining in finished product which would mean they have not been reprocessed from a waste to a saleable material;
3. Whether the previously identified risks to surface water and groundwater are still apparent; and
4. The amount of waste that has been processed and how much is remaining.

During the period 12th April to 14th April 2016 a walkover visit was undertaken at the former Wormtech area (FWA) of MOD Caerwent and a selection of the established boreholes and surface water monitoring locations were sampled. Key staff from DIO and from Crownhill Topsoil Ltd. (CTL), who currently operate a waste processing facility at the FWA, were interviewed as part of the visit. The aims of the interviews were to try to understand and record changes which had occurred at the site since completion of the LQA in early 2014 and to understand how the recovery of the green waste may progress in future. In addition to the walkover visit, an aerial photogrammetry survey was conducted on 27th April 2016 to calculate the volume of waste remaining at the site.

Findings of the Walkover Visit

Since CTL has taken over site management at the FWA within MOD Caerwent, the site appears organised and with no obvious housekeeping issues. The green waste mounds have been re-profiled to create room for CTL's activities including processing the green wastes. The roads in the FWA previously discoloured with wastes, soil and leachate residues are now largely clear; though leachate continues to be generated by the green wastes.

CTL has conducted recovery trials on the green wastes and has derived topsoils from the wastes without blending with other soils. Jacobs has observed very small quantities of plastics in the finished topsoil but CTL has stated that the materials have been tested and comply with BS3882 (2015): Specification for Topsoil. BS3882 allows for up to 0.5% deleterious material content in topsoil and the materials may therefore be compliant, however no validation testing has been undertaken as part of this study.

Minor amounts of the green waste are expected to be unrecoverable by CTL. These residues are mainly comprised of plastics and a local arrangement is in place with DIO's site management team to periodically dispose of waste residues from the treatment process.

At the time of the walkover survey in April 2016, approximately 220 m^3 of the wastes had been recovered as topsoil though no topsoil had been sold or moved off-site.

Evidence of continued leachate generation from the green wastes left by Wormtech was observed during the walkover survey – this was identifiable by brown discolouration and algae in and on the liquids. Leachate was also visible in the surface water drainage ditches close to and within the FWA. Visible evidence of leachate was absent in the down-gradient locations from 500m south of the FWA onwards. Flow in the on-site drainage channels ceased before reaching the Cas Troggy and monitoring locations near the site boundary and at the culvert entrance to the Cas Troggy were dry at the time of the survey.

The rudimentary leachate management system put in place by Wormtech had been removed, except for a small number of roof drainage diversions which were still in place. Although there are partial blockages in the site's

drainage channels, it is likely that during periods of high rainfall, surface water run-off would flow to the Cas Troggy from the FWA. However the increased run-off would also dilute the leachate content.

Findings from Monitoring of Surface Water and Groundwater

Water quality parameters recorded for surface waters at MOD Caerwent generally revealed high electrical conductivity (EC) values, elevated temperatures and reduced dissolved oxygen (DO) at the monitoring points within the FWA. Together with the laboratory analysis results, which showed contaminant concentrations (biological oxygen demand (BOD), chemical oxygen demand (COD), ammoniacal nitrogen, copper, iron, mercury and manganese) in excess of Environmental Quality Standards (EQS) at locations in the FWA, is clear evidence of leachate contamination from the green wastes. Contaminant concentrations reduced with distance from the FWA and no EQS exceedances were recorded in the sample from SW201 which was the furthest down-stream sample between the FWA and the Cas Troggy. It is therefore possible, although not certain, that even were increased rainfall to create a connected flow to the Cas Troggy from the FWA, that flows into the Cas Troggy may not exceed EQS.

Groundwater monitoring also recorded high EC and low DO values at boreholes located nearest to the FWA (BH7 and BH102). Water quality parameters improved with distance from the FWA. Concentrations of ammoniacal nitrogen, manganese and iron recorded the greatest values and exceeded their respective EQS and/or drinking water standards (DWS) at boreholes located at the FWA and within its immediate vicinity. This suggests that leachate from the FWA is percolating into groundwaters. Copper and mercury have been detected in groundwater marginally above their EQS down-gradient of the FWA, mercury was also detected marginally above EQS in BH105 close to the FWA, but these are not considered significant.

Manganese and iron concentrations were recorded above EQS and DWS in several boreholes including those in the FWA. Unusually, concentrations of the metals in groundwater were higher than those measured in the surface water locations SW101 and SW202 which were clearly affected by leachate. This is suggestive of a contributing source of metal contamination other than he green wastes, most probably natural background mineralisation.

Recommendations

Monitoring shows that risks to the aquifer within MOD Caerwent remain high from leachate derived from the green waste. But, risks to wider aquifer remain low. Some metal contamination is evident in perimeter wells but this is unlikely to derive from leachate from the FWA. In the absence of any leachate control measures at the FWA and with continued leachate generation from the wastes it would be prudent to continue with environmental monitoring to determine whether risks to the principal aquifer and off-site stream reduce over time or whether remedial measures are needed.

Controls on the generation of leachate are recommended, either by sheeting over the wastes or by moving the waste into buildings.

In addition, quarterly monitoring of surface water and biannual (6 monthly) monitoring of groundwater is recommended to assess changes in water quality whilst wastes are being processed at the FWA.

If controls are implemented by CTL or the MOD to limit leachate release at the site, it should be possible to reduce the frequency of monitoring to a bi-annual basis.

1. Introduction

Jacobs has been commissioned by Defence Infrastructure Organisation (DIO) to undertake further environmental monitoring at Ministry of Defence (MOD) Caerwent following the Phase 2 Land Quality Assessment (LQA) carried out by SKM Enviros (now Jacobs) in 2013-2014 (finalised July 2015 – Reference 1).

1.1 Background Information

Following the failure of Wormtech Ltd. in 2012, a large quantity of green waste was stockpiled and left at MOD Caerwent. The 2014 LQA demonstrated that leachate derived from the waste posed a risk to local groundwaters and to a lesser degree surface waters in the form of the Cas Troggy Brook. The LQA also included recommendations for remediation of the wastes and environmental monitoring during the remediation period.

Subsequent to the completion of the LQA, a topsoil manufacturing company (Crownhill Topsoil Ltd. (CTL)) based at MOD Caerwent has commenced a waste processing system, using the stockpiled green waste to create saleable topsoil. No supervision or verification of the remediation activities has been undertaken to date, other than visits from the regulatory body Natural Resources Wales (NRW).

It is understood from discussions with DIO that CTL has not been contracted to undertake remediation of the green wastes. CTL's treatment and recovery of the wastes are undertaken on a voluntary basis since it is able to use the materials to create a saleable product.

Further information regarding site setting, site history, current site layout and uses, site sensitivity and previous LQA findings are detailed in Reference 1.

1.2 Aims

Environmental monitoring has been carried out at the site with the aim of determining:

5. Whether the recovery of topsoils from the green wastes is being carried out by CTL is in a manner which minimises environmental impacts;

6. Any obvious flaws in the process, e.g. plastics remaining in finished product which would mean they have not been reprocessed from a waste to a saleable material;

7. Whether the previously identified risks to surface water and groundwater are still apparent; and

8. The amount of waste that has been processed and how much is remaining.

1.3 Scope of Works

The scope of the works for further environmental monitoring included the following tasks:

1. Meeting with CTL's representative on site to discuss recovery works undertaken on the waste mass to date and proposed activities; in particular whether they have identified mounds that they cannot treat.

2. Meeting with MOD's site management team to understand whether there have been any recorded problems with the waste or remediation of the waste since the LQA was undertaken.

3. Conducting a site walkover inspection to assess the general condition of the site, noting any signs of leachate migration and the general suitability of the environmental management.

4. Confirming revised waste volumes using a new photogrammetric survey. The photogrammetric survey will also provide an up to date aerial image of the site.

5. Describing the general condition of stockpiles including the approximate percentage of sealed surfaces; record the materials visible in stockpiles and any visible evidence of leaching from the wastes.

6. Visually examining the topsoil end product for deleterious materials. This would be a superficial examination unless CTL is working the materials over with plant at the time of the visit. It should be appreciated that it is beyond the scope of the current study to determine whether end of waste status is achieved.

7. Assessing whether there is on-going contamination of groundwater and surface water by undertaking a round of monitoring at 10 groundwater monitoring locations and up to 6 surface water monitoring locations in and around the former Wormtech area (currently CTL). The number of surface water monitoring locations available is weather dependant.

8. Recording what happens to deleterious materials, such as plastics, when separated from the green waste and in particular whether they are recycled/disposed of or whether they are left on site.

9. Producing a letter report collating the information gathered in the above tasks.

1.4 Nomenclature

Throughout the report reference is made to the former Wormtech area (FWA) and CTL site which are to all intents and purposes the same area, the former Wormtech area is shown on the site layout plan (Figure 1). Since this report principally concerns risks to the water environment due to Wormtech's operations, the study area is generally referred to as FWA except where describing activities solely relating to Crownhill's current activities and responsibilities where the area is referred to as the CTL site. The study area forms a small part of the wider MOD Caerwent Training Estate which is referred to as MOD Caerwent throughout.

Building numbers referred to in this report are shown on Figure in the 2014 LQA (Reference 1).

The Cas Troggy Brook is referred to by its English name in this report but is elsewhere referred to by its Welsh name Castrogi.

2. Information from Current Site Operators (CTL)

During the site visit on 12th of April 2016, The Managing Director (MD) of Crownhill Topsoil confirmed the points listed below; it should be appreciated that CTL's comments are presented at face value and Jacobs have not sought to verify these:

1. CTL has been issued a permit for their waste treatment activities at the FWA by NRW.
2. CTL's primary activity is the processing and recovery of waste demolition materials and soils for resale as aggregates and soils. Treatment and recovery of the green wastes is a lower priority activity for CTL. The demolition materials treated by CTL are usually sourced from outside the DTE Caerwent site, though CTL have recently processed material from an on-site building (see 17 below).
3. The green waste material is effectively unworkable when wet and CTL's experience to date is that there is generally only a limited period of the year, during summer months, when the material can be dried out sufficiently to begin processing.
4. CTL treat the waste by passing it through a trommel screen, sometimes multiple times until the deleterious materials are satisfactorily removed and the material reaches the desired grading characteristics.
5. Up until autumn 2015, CTL was operating from an area near Buildings 21 and 22 in the south central part of the Caerwent Training Area. However, it took approximately 2.5 hours to move excavation and screening plant from Building 21 to the former Wormtech area. Because screening the green waste was a low priority weather dependant activity, CTL was only able to devote a day or two at a time to the activity and the travel time made this inefficient. Consequently in late 2015, CTL transferred their operations and waste treatment permit to the FWA.
6. The availability of covered buildings for storage of processed or part processed materials at the FWA allows CTL to export finished topsoil and undertake limited amounts of screening year round.
7. When CTL took over the FWA, there was relatively little available space for processing and storage of materials due to the large volumes of green waste left by Wormtech. One of CTL's first actions was to amalgamate and reposition some of the waste mounds in order to create space to process and recover the green waste and also to carry on CTL's own operations of recovering waste soils and demolition materials for reuse.
8. As part of the repositioning of the green waste mounds, CTL moved the wastes away from buildings – they had previously been piled against buildings and leachate was permeating into the buildings and in CTL's opinion also eroding the mortar.
9. CTL undertook an examination of most of the green waste mounds to gauge the potential treatability of the material. Small scale treatment trials have also been undertaken by CTL on a selection of green wastes that purportedly include some of the older wastes with the highest plastics contents. CTL confirmed that the topsoils produced from the treatment trials have been tested and met BS 3882 (2015) specification.
10. CTL confirmed that as of 12th April 2016, none of the manufactured topsoil had been sold and all of the recovered material remained on site at that point. On a return site visit on 27th April, topsoil screening was actively taking place at Building 1008 and topsoil was stockpiled inside the building as shown in Plates 8 – 11 and Plate 12 in Section 4. Visual examination of the finished topsoil by Jacobs showed very small quantities (<1 % by visual estimate) of fragmented plastic film materials present. This does not necessarily prevent compliance with BS 3882 which allows up to 0.5 % visible contaminants of which plastics are permitted to comprise up to 0.25 %. It was beyond the scope of Jacob's current study to undertake verification testing on the topsoil.
11. Topsoil has been produced directly from screening the green waste materials and without mixing or blending with other soils.
12. CTL was of the opinion that none of the green wastes present on site were untreatable by CTL. CTL's MD indicated that CTL was considering the purchase of plant with a 10 mm soil screen which would allow more efficient production of the topsoil and removal of more of the plastics.
13. Deleterious materials, such as plastics removed from the wastes will not be disposed of by CTL and a local agreement has been made between CTL and DIO's site management team to store the deleterious

materials inside one of the buildings in the FWA so that MOD can periodically collect and dispose of the materials. CTL estimate that total plastic content may fill approximately 3 builder's skips (each nominally r 8 cubic yards or 6.1 m^3) with plastics and other waste by-products.

14. CTL plan to continue to process and recover the green wastes but estimate that this will take "a few years" due to the short working season imposed by climatic constraints.
15. CTL confirmed that the end market for the topsoil was also a factor in the overall timescale for recovery of the materials. The main market for CTL's topsoil to date has been the housing development at Llanwern in Newport on former steelworks land. If the local market were to significantly alter then CTL's treatment activities would likely increase or decrease to meet demand.
16. CTL had in 2013 considered the potential use of a blower combined with the soil screen to remove fine plastic fragments and this remains under consideration by CTL as does a 10 mm aperture fine screen.
17. Building 1007 that was fire damaged during Wormtech's occupation has become unsafe since 2013 and CTL recently demolished the building at the request of DIO. The demolition materials derived from the building remain on site (Stockpiles 12 and 13 in Appendix B) pending processing and recovery by CTL.

3. Information from DIO's Site Management Team

The Deputy Range Safety Officer for MOD Caerwent confirmed the following points during a site visit on 12th April 2016:

1. No notable occurrences of leachate have been observed by the DIO site team.
2. No problems with CTL's housekeeping at the FWA have been recorded by DIO.
3. The visual appearance of the FWA is improved due to the efforts by CTL including erecting a new fence on part of the southern edge of the FWA, moved green wastes from the entrance to the FWA and sowing the remaining soil with grass seed.
4. The green waste stockpiles appear (in the Safety Officer's view) to have settled and consolidated since 2013.
5. DIO is aware of a likely residual waste from the processing of the green wastes by CTL and have plans to periodically collect the residual wastes which comprise mainly plastics, and to dispose of these through the MOD Caerwent waste facilities.

4. Walkover Inspection Findings

A walkover inspection of the site was carried out on 12th April 2016; minor additional observations were made during sampling activities carried out 13th to 14th April and during the aerial photogrammetry survey on 27th April. Observations from the walkover inspection are listed in Table 4.1 with additional comment following the table. Unless otherwise stated, references to stockpiles in the table refer to 2016 surveyed locations as shown on Figure 1 in Appendix B, rather than stockpile locations surveyed in 2013 which share the same reference nomenclature.

Borehole and surface water monitoring point locations are shown on Figure 1.

Table 4.1 : Observations Made During Site Walkover Visit

Plate Ref.	Description of Features	Photographs of Features
1	Stockpiles identified in 2013 as A10 and A11 (see 2014 LQA for locations) south of Buildings 1009 and 1008 respectively have been moved. The ground here has been seeded with grass by CTL and was starting to germinate and grow at the time of the site visit in April 2016.	
2	The former small leachate collection pit immediately east of the emergency water supply has been infilled and a new shallow sediment settlement pond created, purportedly at the request of NRW. This settlement pond is unlined and collected run-off either soaks to ground or overspills the pond and flows south and west over surrounding ground. The settlement pond was sampled as SW202.	

Plate Ref.	Description of Features	Photographs of Features
3	Building 1007, formerly damaged by fire, has been demolished by CTL. The demolition rubble (Stockpile A12 - centre of plate) and steel reinforcement (Stockpile A13 – right of plate) remained on site in April 2016 but were planned to be recycled in the near future.	
4	Green wastes formerly piled against building walls have been re-profiled in most areas and there is now a small walkway, approx.. 1m wide between waste piles and the buildings. CTL's director has stated that leachate from the green waste was having detrimental effects on the brickwork mortar.	
5	CTL sells aggregates in addition to topsoil and these are stored in temporary bays outside Building 1008.	

Plate Ref.	Description of Features	Photographs of Features
6	The CTL site accepts waste soils and demolition materials of various types and recycles these as secondary aggregates, soil and topsoil.	
7	A crusher-screener is used to process sub-soils, green wastes and demolition materials by separating the fine and coarse fractions.	
8	A large hole has been cut into the side of Building 1008 in order to deposit processed materials directly from the crusher/screener into the interior of the building. This is of particular use for topsoil as it helps maintain moisture content closer to optimum.	

Plate Ref.	Description of Features	Photographs of Features
9	Processed topsoil material.	
10	Close up view of finished topsoil shown in Plate 9.	

Plate Ref.	Description of Features	Photographs of Features
11	Close up view of part treated green waste.	
12	During the site visit on 27th March the interior of Building 1008 had started to fill up with topsoil, indicating that some topsoil processing had been undertaken in the preceding fortnight. These soils were not able to be included in the photogrammetric survey but their total volume is estimated to be approximately 220 m^3.	

Plate Ref.	Description of Features	Photographs of Features
13	A freshly exposed face in a green waste pile (Stockpile A8).	
14	In the left of the photo is the same green waste pile shown in Plate 13. Small quantities of brown leachate emanate from the waste. Background right is an excavator spreading the freshly excavated material in order to dry it out (Stockpile A10 in Appendix B).	

Plate Ref.	Description of Features	Photographs of Features
15	Green waste in Stockpile A9, some of the waste had recently been moved from land to the west (former 2013 Stockpile locations A10 and A11).	
16	General appearance of green waste piles – recently disturbed material immediately east of Building 1006 (Stockpile A6).	

Plate Ref.	Description of Features	Photographs of Features
17	General appearance of green waste piles – vegetated material between Buildings 1004 and 1005 (Stockpile A5). Leachate also being generated (base of plate)	
18	Leachate being generated from green waste pile shown in Plate 14	

Plate Ref.	Description of Features	Photographs of Features
19	Leachate being generated from Stockpile A5.	
20	Leachate derived from Stockpile A4 between Buildings 1002 and 1003. Leachate runs along road and soaks into the verge adjacent to Building 1002 or evaporates.	

Plate Ref.	Description of Features	Photographs of Features
21	Stockpile A7. CTL also process waste wood and timber on site – turning it into wood chip.	
22	Stockpile A1. Chipped wood stored in in a pile located between Buildings 1003 and 1004. No significant sign of leachate was observed around the wood chip pile.	

Plate Ref.	Description of Features	Photographs of Features
23	Chipped wood is also baled on site.	
24	CTL was storing their own soils within Building 1003. Estimated volume of the soils was 180 m^3.	

Plate Ref.	Description of Features	Photographs of Features
25	Evidence of leachate visible in the ditch at SW101.	
26	View of SW105 showing shallow clear standing water in the ditch.	
27	SW201 – the furthest downstream point in the drainage ditch which contained clear standing water during the site visits.	

Plate Ref.	Description of Features	Photographs of Features
28	SW102 – dry at the time of the site visits	
29	View of the Field Culvert. The field was dry at the time of the site visits.	
30	View of SW104 at the downstream side of the culvert on the Cas Troggy. The water was clear and had a moderate flow.	

Plate Ref.	Description of Features	Photographs of Features
31	View of SW103 at the upstream side of the culvert on the Cas Troggy. The water was clear and had a moderate flow.	
32	Equipment used for aerial photogrammetric survey.	

The walkover observations confirmed that the majority of stockpiled green waste material is located on hardstanding; however Stockpiles A9 and A10 are located on soil.

There was evidence of leachate across the FWA, typically found at the base of green waste stockpiles. Flowing leachate appeared to be brown in colour (Plates 14 and 17) whilst stagnant leachate appeared to have some associated algae and scum on the surface (Plates 19 and 20). None of the leachates had a significant odour, whereas in 2013 the leachate and green wastes had strong odours. Although, the recent surveys took place during a relatively dry period and it is likely that leachate generation would increase in wetter periods. No leachate was observed to be emanating from any of CTL's waste materials or products.

The settlement pond shown in Plate 2 has been constructed by CTL to collect runoff from the site and enable sediment to settle out of the runoff before discharging from the CTL site. There is no engineered connection between the settlement pond and the site's drainage channels and it appears that the pond also acts as a soakaway. Although during and following rainfall events the pond would almost certainly be overtopped by surface water runoff which would then flow southwards across a short grassed slope to the nearby road and then onto a lower grassed area where the runoff would potentially pool and soakaway.

Although the settlement pond at CTL is designed to collect some of the runoff from the site, there is evidence of leachate having migrated into nearby surface watercourses. As displayed in Plate 25, visible evidence of leachate was detected at SW101, located approximately 115 m west of the main entrance to CTL. The water contained suspended sediment and organic material with green scum on the surface, similar to the leachate observed across the CTL site as in Plates 19 and 20. There was no odour at SW101. There appeared to be a partial blockage of the culvert at this location, however leachate was visible on either side of the culvert so it is unlikely that the blockage was other than partial. Further blockages and dry sections of ditch were apparent in the ditch between SW101 and SW105.

Downstream of a point close to Building 715, the ditch was dry (i.e. SW102, Field Drain and Field Culvert were dry). A new surface water sampling point, SW201, was created immediately upstream of this location. The water in the ditch here and at SW105 was clear and free of any odours. It was not certain during the monitoring round whether the water in these two locations derived from the FWA leachate or from local surface runoff.

The Cas Troggy Brook (SW103 and SW104), was clear and free of any odours with a moderate flow rate in both sampling locations.

5. Volumetric Survey of Waste Mounds

An aerial photogrammetric survey of the FWA was undertaken on 27th April 2016 by Intelligent Mapping Solutions Ltd. The results of the volumetric survey are shown in Appendix B.

Fourteen separate material stockpiles were identifiable from the aerial survey. These comprised green wastes dating from the Wormtech occupation of the FWA and wider variety of demolition wastes, soil wastes and recovered products owned by CTL as detailed in Table 5-1.

Table 5.1 : Description of Waste Piles Identified in the Aerial Survey

Pile Ref.	Volume (m^3)*	Pile Content Description (based on content visible at surface)
Green Waste Material Stockpiles (Wormtech)		
A3	2,780	Green Waste
A4	500	Green Waste
A5	1,520	Green Waste
A6	180	Green Waste
A8	2,280	Green Waste
A9	1,580	Green Waste
A10	550	Green Waste - in the area used for drying out material
Sub-total	**9,390**	
CTL Material Stockpiles		
A1	1,110	Chipped Wood
A2	130	Unprocessed demolition rubble waste
A7	680	Unprocessed waste wood
A11	4,650	Waste soils and demolition rubble
A12	160	Metal rebar and structural steel wastes
A13	270	Large fraction demolition rubble and asphalt wastes
A14	240	Waste soils and demolition rubble
Sub-total	**7,240**	

Notes: * the volumetric calculations include assumptions that affect the accuracy and precision of the calculations; these include:

- ground level beneath a stockpile is the same as the ground adjacent to the stockpile.
- the photogrammetric survey does not "see" through vegetation and where vegetation is present on stockpiles the surface height of the stockpiles will be overestimated.

In addition to the stockpiles depicted in the aerial survey, processed and part processed topsoils were also stored inside Building 1008 and are estimated by Jacobs to approximately comprise a further 220 m^3. The total volume of green wastes and derived topsoils on site in April 2016 are therefore approximately 9,610 m^3. This is approximately 73 % of the volume of the waste mounds as measured in 2013. Direct comparison of individual stockpiles identified in the recent survey with stockpiles measured in 2013 has not been practical as the green wastes have been moved and consolidated in the intervening period.

Comments from the Deputy Range Safety Officer (Section 3) indicate that waste density is likely to have increased. However, on the basis that no materials have been removed from the site the overall mass of green waste material will still be approximately 12,500 tonnes.

6. Surface Water and Ground Water Sampling

6.1 Sampling Methodology

Sampling methodology was unchanged from the 2014 LQA (Reference 1).

6.2 Sampling Locations

The 2014 LQA (Reference 1) established a total of 11 groundwater and 7 surface water monitoring locations in the FWA and the area hydraulically down-gradient of the FWA within MOD Caerwent and the immediate surrounding area. It was planned to resample the majority of these locations (all except BH101 and Field Drain) as part of the current study; but during the monitoring period two of the planned surface water monitoring locations (SW102 and Field Culvert) were dry. However, as outlined in Section 4, two new surface water monitoring locations (SW201 and SW202) were created in response to walkover observations. The Field Drain location was also dry during the monitoring round.

Groundwater and surface water locations monitored during this round are detailed in Table 6.1 below and illustrated on Figure 2 together with indicative groundwater contours. The dry surface water locations are also shown since the absence of flowing water is a useful observation.

Table 6.1 : Summary of Surface Water and Groundwater Sampling Locations

Location	Description
Surface Water Sampling Locations	
*SW202	New shallow sediment settlement pond within CTL site.
SW101	Onsite drainage ditch immediately southwest of FWA.
SW105	Onsite drainage ditch down-gradient of the FWA.
*SW201	New surface water monitoring location (onsite drainage ditch) near Building 715, situated between SW105 and SW102.
SW102	Onsite drainage ditch, SW part of MOD Caerwent at perimeter fence.
Field Culvert	Entrant to Cas Troggy culvert from field outside MOD Caerwent's SE boundary fence
SW103	On Cas Troggy brook, upstream of culvert entry.
SW104	On Cas Troggy brook, downstream of culvert entry.
Groundwater sampling locations	
BH103	Up-gradient borehole on northern edge of FWA close to building 845.
BH102	Southern edge of FWA
BH7	Southern edge of FWA
BH104	South-eastern edge of FWA.
BH105	South-western edge of FWA
BH105A	South-western edge of FWA (shallow borehole adjacent to BH105)
BH106	Down-gradient borehole on MOD Caerwent southern boundary
BH106A	Down-gradient borehole on MOD Caerwent southern boundary (shallow borehole adjacent to BH130)
BH107	Down-gradient borehole between FWA and MOD Caerwent southern boundary
BH130	Down-gradient borehole on MOD Caerwent southern boundary

Notes: * represents new surface water sampling locations.

6.3 Water Quality Field Results

6.3.1 Surface Waters

Water quality parameter readings were taken at the point of sampling surface waters. Measurements were taken for pH, electrical conductivity (EC), temperature, reduction/oxidation potential (redox) and dissolved oxygen (DO). The recorded values have been used to give a general indication of the water quality within the stream and to give immediate pH and EC values rather than rely on those supplied following laboratory analysis as the samples' composition can alter during the holding time prior to analysis. Table 6.2 details the surface water quality parameters at the point of sampling.

Table 6.2: Surface Water Quality Parameters at the Point of Sampling

Surface Water Quality Field Results								
Location		Temp.	pH	Electrical Conductivity	Redox Potential	Dissolved Oxygen	Comments *
		°C	pH .Units	µS	mV	%	
Former Wormtech Area	SW202	23.1	8.3	760	26	76	Light to medium brown with suspended sediment. Standing water.
	SW101	19.5	8.0	1577	83	92	Dark brown, suspended sediment and organic material. Standing water with green scum on the surface. No odour.
	SW105	18.9	7.7	345	81	119	Clear, low flow.
	SW201	13.0	8.5	290	41	120	Standing water adjacent to culvert.
Cas Troggy brook	SW102	-	-	-	-	-	Dry
	Field Culvert	-	-	-	-	-	Dry
	SW103	11.3	8.1	190	67	97	Clear, moderate flow.
	SW104	10.4	8.1	191	59	97	Clear, moderate flow.

Notes: * Detectable odours were absent at all monitoring locations

Temperatures within surface waters generally decreased with distance from the FWA. This could reflect changes in ambient air temperature throughout the day as sampling locations furthest from the FWA were sampled first followed sequentially by the remaining locations upstream. However, this could also be indicative of the breakdown of organic material within leachate which has entered surface waters closest to the FWA.

The pH of surface waters was generally neutral to slightly alkaline but with no geographical distribution pattern.

EC was elevated at surface water locations at and near the FWA. CTL's settlement pond (SW202) recorded a slightly lower EC value when compared to SW101 indicating a greater proportion of dissolved salts content in CTL's settlement pond, likely due to leachate. EC values decreased with distance from the TWA, likely due to dilution and attenuation. The Cas Troggy Brook (SW103 and SW104) recorded a high DO and low EC value. DO was high at all locations, as would be expected in surface waters, although SW101 and SW202 recorded the lowest values likely due to the presence of leachate. Redox potential showed no discernible trend, with the lowest value being recorded in SW202 (CTL settlement pond).

Based on the limited field water quality parameters measured, conditions at the Cas Troggy Brook are indicative of healthy surface water features.

6.3.2 Groundwaters

As with surface water samples, water quality parameter readings were taken at the point of sampling. During purging of the boreholes, water quality parameter readings were used to determine when abstracted waters had ceased to vary by any significant amount and were therefore assessed to be representative of the aquifer. The results of these field measurements can give an indication of general groundwater quality. Table 6.3 details groundwater quality parameters at the point of sampling.

Table 6.3: Groundwater Quality Parameters at the Point of Sampling

Groundwater (GW) Quality Field Results								
Location	Depth to GW	Depth to Base	Temp.	pH	Electrical Conductivity	Redox Potential	Dissolved Oxygen	Observations during purging
	m bgl	m bgl	°C	pH Units	µS	mV	%	
Up-gradient of FWA								
BH103	19.16	-	11.4	7.0	531	64	66	Orangish brown with suspended sediment.
Boreholes at or near FWA								
BH7	8.15	22.77	13.2	6.8	1198	56	0	Dark grey flow, no odour.
BH102	8.00	19.31	12.6	6.7	1220	20	0	Initially brownish orange in colour with suspended ochre precipitate. Becoming clearer with moderate orange ochre tinge.
BH104	6.45	15.29	11.3	6.9	567	46	6	Ran clear.
BH105	2.33	14.12	11.5	7.2	509	69	52	Initially very silty. Became clear with slight brown tinge.
BH105A	2.45	5.62	10.7	6.9	486	73	44	Greyish brown tinge with some suspended sediment.
Down-gradient of FWA								
BH107	13.91	17.66	11.8	7.4	364	48	91	Light to medium brown with suspended sediment.
BH106	13.39	19.50	11.9	7.7	326	48	81	Ran clear.
BH106A	3.09	5.48	9.4	6.9	436	60	49	Light to medium brown with suspended sediment.
BH130	2.99	15.78	10.5	7.1	363	53	62	Ran clear.

Groundwater levels have been used to create an indicative groundwater contour plan (Figure 2), which shows groundwater flows in an approximately southerly direction in this part of MOD Caerwent. Due to the limited number of data points, only an indicative groundwater flow direction could be determined from the groundwater level data. Additionally, the groundwater level recorded at BH103 is unreliable as the borehole was partially blocked and the measured groundwater level was anomalously high in comparison with previous results, potentially due to perched groundwater or recharge from surface water infiltration. As a consequence BH103 is unlikely to be representative of up-gradient conditions in the limestone aquifer.

Groundwater pH across the site was approximately neutral in all samples.

EC values varied across the site with the highest values recorded in boreholes located at the FWA (BH7 and BH102). EC values appeared to decrease with distance from the FWA site suggesting that boreholes within the immediate vicinity of the FWA are subject to leachate percolation with the effects and presence of leachate in groundwaters generally decreasing with distance from the FWA.

DO is relatively high for groundwater, with exception of BH7, BH102 and BH104 which recorded values between 0 and 5.7 %; likely due to leachate percolation from the FWA. Elevated DO values in the remaining boreholes could be a function of recharge from moderate rainfall which took place in the days preceding the monitoring round.

Boreholes within the FWA recorded the highest temperature values, indicative of the breakdown of organic material present within the leachate.

The lowest redox potential value was recorded in BH102, where the redox was 50% lower than in all other boreholes. Although not indicative of significantly reductive conditions, this does provide further evidence of a local leachate impact on the groundwater.

6.4 Analyses Scheduled at Surface Water and Groundwater Locations

During this round of environmental monitoring, six surface water samples and ten groundwater samples were collected. These samples were scheduled for following analyses:

- Calcium, dissolved organic carbon (DOC);
- Biochemical oxygen demand (BOD), chemical oxygen demand (COD); chloride, ammoniacal nitrogen; and
- Arsenic, boron, cadmium, chromium (total), chromium (hexavalent), copper, iron (total), mercury, manganese, nickel, lead and zinc.

6.5 Methodology of Assessment

The methodology of assessment remains largely unchanged from the 2014 LQA. The only significant change is the use of revised Environmental Quality Standards (EQS) to assess risks to surface waters. In December 2015, previous EQS regulations were replaced in England and Wales by the "*Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015*". For most parameters, the EQS's contained within the 2015 directions remain the same as those used in the 2014 LQA. However, key changes have been introduced. The changes relevant to this report include:

- Five metals (copper, lead, nickel, manganese and zinc) now have an EQS set for 'bioavailable metal' which are calculated using the dissolved metal concentration, pH, calcium concentration and DOC.
- Metals, with exception to cadmium, no longer rely on the 'hardness class'.

As such, laboratory results detailed in the tables below list these five metals as 'dissolved' for screening against Drinking Water Standards (DWS) and 'bioavailable' for screening against EQS's. One sample was analysed for hardness so that cadmium can be appropriately assessed against its relevant EQS.

It should be noted that if an EQS or DWS is exceeded, the impacts may not necessarily be significant. Additional work would be required in order to assess the extent of any impact.

There are no current UK EQS for chemical oxygen demand (COD); in order to set the data in context sample analyses have been compared against the now repealed Surface Water Directive (Reference 6) value of 30 mg O_2/L.

6.6 Surface Waters Assessment

Six surface water samples from onsite ditches, offsite streams and a settlement lagoon at the FWA were collected on April 13th 2016 and analysed for the contaminants listed in Section 6.4. Table 6.4 presents the assessment of surface water analyses against EQS and compares with results measured in the 2014 LQA. Table 6.5 summarises the recorded EQS exceedances for surface water and illustrates the scale of exceedances and how these are distributed in the sampling locations.

Table 6.4: Assessment of Contaminants present in Surface Waters (exceedances highlighted)

Determinand	Units	Number of Samples	EQS (exceeded)	Min.	Max.	Previous min	Previous Max	Location of Exceedances (highest in bold)
pH	pH Units	6	6.0 (0) to 9.0 (0)	8.1	8.7	6.9	8.7	
EC	µS/cm	6	-	190	1577	190	3600	
BOD (settled)	mg O2/L	6	4 (2)	1.1	12	<4.0	140	SW202 and **SW101**
COD	mg O_2/L	6	30 (2) *	4.2	300	<10	720	**SW202** and SW101
Chloride	mg/L	6	250 (0)	14	230	9.1	420	
Ammoniacal Nitrogen	mg/L	6	0.3 (6)	0.05	22	<0.01	63	SW202, **SW101**, SW105, SW201, SW103 and SW104.
DOC	mg/L	6	-	1.10	93.6	-	-	
Calcium	µg/L	6	-	32	160	20	110	
Arsenic (dissolved)	µg/L	6	50 (0)	0.27	5.37	<1.0	28	
Boron (dissolved)	µg/L	6	2000 (0)	17	220	<20	390	
Cadmium (dissolved)	µg/L	6	0.15 (0)	<0.02	0.10	<0.08	0.37	
Chromium (dissolved)	µg/L	6	4.7 (0)	0.3	2.4	<1.0	11	
Chromium VI	µg/L	6	3.6 (0)	<5	<5	-	-	
Copper (bioavailable)	µg/L	6	1 (4)	0.4	23	<1.0	27	**SW202**, SW101, SW103 and SW104.
Iron (total)	µg/L	6	1000 (1)	39	1800	<20	4900	**SW202** and SW101
Mercury (dissolved)	µg/L	6	0.07 (1)	<0.05	0.08	<0.50	0.88	**SW101**
Manganese (bioavailable)	µg/L	6	123 (2)	3.80	465	<1.0 *	1500 *	SW202 and **SW101**
Nickel (bioavailable)	µg/L	6	4 (0)	1.67	3.77	<1.0 [2]	32 [2]	
Lead (bioavailable)	µg/L	6	1.2 (0)	0.06	0.22	<1.0 *	110 *	
Zinc (bioavailable)	µg/L	6	12.3 (0)	0.82	3.43	<1.0 *	72 *	
Hardness	mg $CaCO_3$/L	1	-	123	123	-	-	

Notes: [1] Not an EQS – screening value is from the repealed Surface Water Directive (Reference 6)

[2] Previous max and min for metals relate to the dissolved concentrations but are here compared with bioavailable concentrations.

Table 6.4 shows contaminant concentrations within surface water samples were below their corresponding EQS values for all determinands with exception to BOD, ammoniacal nitrogen, copper, iron, mercury and manganese.

In general, surface water quality appears to have improved when compared to the results from the 2014 LQA. Only iron has shown significant increase in maximum concentrations.

Table 6.5: Summary of Water Quality Exceedances for Surface Waters Sampled 13th April 2016 (scale of exceedances colour coded – see notes)

Location of Sample	BOD	COD	Ammoniacal Nitrogen	Copper (bioavailable)	Iron (dissolved)	Mercury (dissolved)	Manganese (bioavailable)
	mg O_2/L	mg O_2/L	mg/L	µg/L	µg/L	µg/L	µg/L
EQS	4	30 [1]	0.3	1	1000	0.07	123
Onsite Surface Water Monitoring Locations at CTL							
SW202	9.6	210	6.5	23	1800	0.06	380
SW101	12	300	22	1.2	1400	0.08	465
Onsite Surface Water Monitoring Locations Downstream of CTL							
SW105	1.1	4.2	1.20	0.4	39	<0.05	18
SW201	2.2	5.2	0.21	0.9	46	<0.05	16
SW102	DRY						
Offsite Surface Water Monitoring Locations at Cas Troggy brook							
SW103	1.2	6.3	0.05	1.1	90	<0.05	3.8
Field Culvert	DRY						
SW104	1.2	7.3	0.14	1.02	200	<0.05	8.9

Notes: [1] Not an EQS – screening value is from the repealed Surface Water Directive (Reference 6)

[2] The scale of exceedances has been illustrated by shading of cells in the table,
RED = >10 x EQS; YELLOW >5 x EQS; GREY = no exceedance of EQS

Table 6.5 shows that significant EQS exceedances occurred only within the FWA and SW105. It also shows that contaminant concentrations decreased with distance from the FWA to the point at SW201 where contaminant concentrations had all fallen to below EQS.

It is likely that the metal contamination, particularly iron and manganese is in part due to the background geology; this is discussed in detail in Section 6.8.

6.7 Groundwater Assessment

Ten groundwater samples were collected from boreholes at MOD Caerwent between 13th and 14th April 2016 and analysed for the contaminants listed in Section 4.1.3. The assessment for groundwater samples has been grouped into locations up-gradient of the FWA; locations within or very close to the FWA; and locations down-gradient of the FWA.

6.7.1 Assessment of Groundwater Contamination Up-gradient of the FWA

One up-gradient borehole, BH130, was monitored as part of the current study and the data is assessed in Table 6.6 and the following text. As stated in Section 6.2.3, there is some uncertainty over whether the borehole is truly reflective of up-gradient aquifer conditions.

Table 6.6: Assessment of Contaminants in Groundwater Up-Gradient of the FWA (BH103) (Exceedances highlighted)

Determinand	Units	Number of Samples	DWS (exceeded)	EQS (exceeded)	BH103	Previous min*	Previous Max*
pH	pH Units	1	6.5 to 10 (0)	6 to 9 (0)	7.0	7.0	7.1
EC	µS/cm	1	2500 (0)	-	531	660	760
BOD (settled)	mg O_2/L	1	-	4 (0)	<1.0	28	28
COD	mg O_2/L	1	30 (0) [1]	30 (0) [1]	19	20	24
Chloride	mg/L	1	250 (0)	250 (0)	27	8.8	45
Ammoniacal Nitrogen	mg/L	1	0.39 (1)	0.3 (1)	0.42	<0.01	0.06
DOC	mg/L	1	-	-	1.14	-	-
Calcium	µg/L	1	250 (0)	-	110	95	150
Arsenic (dissolved)	µg/L	1	10 (0)	50 (0)	1.4	<1.0	<1.0
Boron (dissolved)	µg/L	1	1000 (0)	2000 (0)	78	81	1100
Cadmium (dissolved)	µg/L	1	5 (0)	0.15 (0)	<0.02	<0.080	<0.080
Chromium (dissolved)	µg/L	1	50 (0)	4.7 (0)	0.6	<1.0	3.2
Chromium VI	µg/L	1	-	3.6 (0)	<5.0	<5.0	-
Copper (dissolved)	µg/L	1	2000 (0)	-	1	<1.0	<1.0
Copper (bioavailable)	µg/L	1	-	1 (0)	0.29	-	-
Iron (total dissolved)	µg/L	1	200 (1)	1000 (1)	3600	240	240
Mercury (dissolved)	µg/L	1	1 (0)	0.07 (0)	0.05	<0.50	<0.50
Manganese (dissolved)	µg/L	1	50 (1)	-	1200	15	15
Manganese (bioavailable)	µg/L	1	-	123 (0)	97	-	-
Nickel (dissolved)	µg/L	1	20 (0)	-	1.9	<1.0	1
Nickel (bioavailable)	µg/L	1	-	4 (0)	1	-	-
Lead (dissolved)	µg/L	1	10 (0)	-	<0.2	<1.0	<1.0
Lead (bioavailable)	µg/L	1	-	1.2 (0)	0.18	-	-
Zinc (dissolved)	µg/L	1	5000 (0)	-	1.3	1.5	7.3
Zinc (bioavailable)	µg/L	1	-	12.3 (0)	0.83	-	-

Notes: [1] Not an EQS – screening value is from the repealed Surface Water Directive (Reference 6)

[2] Previous max and min values include determinand values recorded in BH103 and BH111, however, during this monitoring round only BH103 was sampled.

Iron concentrations in BH103 were substantially higher than both the DWS and EQS by factors of 18 and 4 respectively. THE DWS for manganese was exceeded by a factor of 24. The EQS and DWS for ammoniacal nitrogen were also marginally exceeded.

This borehole is located slightly up-gradient from the FWA, though the water level in the borehole was anomalously high indicating possible infiltration of perched water or surface water run-off which could account for the elevated contamination. It is possible that the contamination found at BH103 arises from a source other than the green waste in the FWA. Monitoring of a wider array of up-gradient boreholes would be needed to determine whether this is "pancaked" contamination from the FWA or from another source external to the FWA.

In comparison with the 2014 results a falling contaminant concentration trend is not apparent at BH103. Ammoniacal nitrogen, arsenic, copper, iron, nickel and manganese have increased in concentration in comparison with the measurements made during the 2014 LQA.

6.7.2 Assessment of Groundwater Contamination within the FWA

Five monitoring wells within or close to the FWA were sampled in the current study; the data is assessed in Table 6.7 discussed in the text following the table.

Table 6.7: Assessment of Contaminants in Groundwater at or very close to the FWA (BH102, BH104, BH105, BH105A, BH7) (Exceedances highlighted).

Determinand	Units	Number of Samples	DWS (exceeded)	EQS (exceeded)	Min.	Max.	Previous min*	Previous Max*	Location of Exceedances (highest in bold)
pH	pH Units	5	6.5 to 10 (0)	6 to 9 (0)	7.6	8.0	7.0	7.6	
EC	µS/cm	5	2500 (0)	-	486	1335	620	1700	
BOD (settled)	mg O_2/L	5	-	4 (0)	<1.0	1.5	<4.0	68	
COD	mg O_2/L	5	30 (2) [1]	30 (2) [1]	7.2	53	14	270	**BH102** and BH7.
Chloride	mg/L	5	250 (0)	250 (0)	14	190	22	260	
Ammoniacal Nitrogen	mg/L	5	0.39 (2)	0.3 (2)	0.046	2.7	0.12	23	**BH102** and BH7.
DOC	mg/L	5	-	-	0.73	17.2	-	-	
Calcium	µg/L	5	250 (0)	-	4.2	10	84	220	
Arsenic (dissolved)	µg/L	5	10 (0)	50 (0)	0.18	0.84	<1.0	6.7	
Boron (dissolved)	µg/L	5	1000 (0)	2000 (0)	21	100	<20	190	
Cadmium (dissolved)	µg/L	5	5 (0)	0.15 (0)	<0.02	0.04	<0.080	0.47	
Chromium (dissolved)	µg/L	5	50 (0)	4.7 (0)	<0.2	0.7	<1.0	<1.0	
Chromium VI	µg/L	5	-	3.6 (0)	<5.0	<5.0	-	-	
Copper (dissolved)	µg/L	5	2000 (0)	-	1.6	7.2	<1.0	23	
Copper (bioavailable)	µg/L	5	-	1 (0)	0.05	0.74	-	-	
Iron (total dissolved)	µg/L	5	200 (2)	1000 (2)	36	4600	150	700	**BH102** and BH7.
Mercury (dissolved)	µg/L	5	1 (0)	0.07 (1)	<0.05	0.08	<0.50	<0.50	**BH105**.
Manganese (dissolved)	µg/L	5	50 (2)	-	0.73	1800	<1.0	1800	**BH102** and BH7.
Manganese (bioavailable)	µg/L	5	-	123 (2)	0.28	621	-	-	**BH102** and BH7.
Nickel (dissolved)	µg/L	5	20 (0)	-	1.2	16	<1.0	13	
Nickel (bioavailable)	µg/L	5	-	4 (0)	0.6	2.0	-	-	
Lead (dissolved)	µg/L	5	10 (0)	-	<0.2	0.8	<1.0	1	
Lead (bioavailable)	µg/L	5	-	1.2 (0)	0.01	0.20	-	-	
Zinc (dissolved)	µg/L	5	5000 (0)	-	1.9	4.7	2.7	17	
Zinc (bioavailable)	µg/L	5	-	12.3 (0)	0.45	2.80	-	-	

Notes: [1] Not an EQS – screening value is from the repealed Surface Water Directive (Reference 6)

[2] Previous max and min values also include determinand values recorded in BH101. This location was not sampled during this monitoring round.

In close agreement with insitu water quality testing, chemical analysis results for BH102 and BH7 reflect evidence of leachate contamination. Ammoniacal nitrogen and COD were elevated above EQS and chloride also elevated but below EQS in both of these boreholes.

In the remaining three boreholes, BH104, BH105 and BH105A, only a single EQS exceedance was recorded. This was for a marginal exceedance of the mercury screening criteria in BH105; though this may be due to background geology rather than leachate as . The EQS for mercury was marginally exceeded in the sample from BH105 though the concentration was very close to limits of detection and the occurrence is not considered significant.

EQS and DWS were exceeded for three contaminants in BH102 and BH7 on the southern edge of the FWA; these contaminants were ammoniacal nitrogen, iron and manganese. The magnitudes of the exceedances were as high as a factor of 23 times DQS for iron and 9 times EQS for ammoniacal nitrogen, both recorded in BH102.

Contaminant concentrations were generally lower than maxima measured in 2013 – 2014, the exception being iron, which recorded approximately 7 times the previous maximum concentration for this area in BH102. Nickel and boron concentrations were also marginally higher than previous maxima.

6.7.3 Assessment of Groundwater Contamination Down-Gradient of the FWA

Four monitoring wells down-gradient of the FWA were sampled in the current study; the data is assessed in Table 6.8 and the text following the table.

Table 6.8: Assessment of Contaminants in Groundwater Down-Gradient of the FWA (BH106, BH106A, BH130 & BH107) (Exceedances highlighted)

Determinand	Units	Number of Samples	DWS (exceeded)	EQS (exceeded)	Min.	Max.	Previous min	Previous Max	Location of Exceedances (highest in bold)
pH	pH Units	4	6.5 to 10 (0)	6 to 9 (0)	7.8	7.9	7.4	7.8	
EC	µS/cm	4	2500 (0)	-	326	436	420	570	
BOD (settled)	mg O_2/L	4	-	4 (0)	<1.0	1.3	<4.0	<4.0	
COD	mg O_2/L	4	30 (0) [1]	30 (0) [1]	5.1	29	<10	18	
Chloride	mg/L	4	250 (0)	250 (0)	8.7	18	6.9	17	
Ammoniacal Nitrogen	mg/L	4	0.39 (0)	0.3 (0)	0.041	0.290	<0.01	0.35	
DOC	mg/L	4	-	-	0.57	2.02	-	-	
Calcium	µg/L	4	250 (0)	-	2.7	75	77	160	
Arsenic (dissolved)	µg/L	4	10 (0)	50 (0)	<0.15	0.35	<1.0	1.2	
Boron (dissolved)	µg/L	4	1000 (0)	2000 (0)	18	60	210	1300	
Cadmium (dissolved)	µg/L	4	5 (0)	0.15 (0)	<0.02	0.04	<0.08	<0.08	
Chromium (dissolved)	µg/L	4	4.7 (0)	50 (0)	0.4	1.0	<1.0	<1.0	
Chromium VI	µg/L	4	-	3.6 (0)	<5.0	<5.0	-	-	
Copper (dissolved)	µg/L	4	2000 (0)	-	<0.5	2.9	<1.0	<1.0	
Copper (bioavailable)	µg/L	4	-	1 (1)	0.01	1.33	-	-	**BH130**
Iron (total dissolved)	µg/L	4	200 (3)	1000 (3)	7	2900	33	73	BH106, **BH106A, BH107**
Mercury (dissolved)	µg/L	4	1 (0)	0.07 (2)	<0.05	0.1	<0.50	<0.50	**BH106A**, BH130
Manganese (dissolved)	µg/L	4	50 (2)	-	0.79	440	<1.0	<1.0	BH106, **BH107**
Manganese (bioavailable)	µg/L	4	-	123 (1)	0.67	203.12	-	-	BH106
Nickel (dissolved)	µg/L	4	20 (0)	-	0.9	2.3	<1.0	<1.0	

Determinand	Units	Number of Samples	DWS (exceeded)	EQS (exceeded)	Min.	Max.	Previous min	Previous Max	Location of Exceedances (highest in bold)
Nickel (bioavailable)	µg/L	4	-	4 (0)	0.90	3.36	-	-	
Lead (dissolved)	µg/L	4	10 (0)	-	<0.2	0.2	<1.0	<1.0	
Lead (bioavailable)	µg/L	4	-	1.2 (0)	0.10	0.20	-	-	
Zinc (dissolved)	µg/L	4	5000 (0)	-	1.0	3.6	<1.0	5.3	
Zinc (bioavailable)	µg/L	4	-	12.3 (0)	1	2.18	-	-	

Notes: [1] Not an EQS – screening value is from the repealed Surface Water Directive (Reference 6)

In boreholes located down-gradient of the FWA, the common leachate indicator compounds ammoniacal nitrogen, BOD, COD, chloride were below EQS which is in close agreement with the insitu testing results in Section 6.3.2.

However, all of the boreholes except recorded at least one EQS exceedance for metals, albeit the exceedances were either marginal or probably attributable to background geology which is discussed in Section 6.8. Contaminants with concentrations in excess of EQS comprised bioavailable copper and dissolved iron, mercury and manganese.

It is unlikely that contamination currently measured in these perimeter wells would manifest in surface water as a result of groundwater baseflow from the FWA. This is in view of the marginal nature of the EQS exceedances, depth of the groundwater and distance to the Nedern Book, even assuming the brook is groundwater fed.

The DWS for manganese and iron were also exceeded in BH106 and BH107 and iron DWS was also exceeded in BH106A. The scale of exceedance was a factor of 9 in BH107 and a factor of 5 in BH106. BH106 is close to the perimeter of MOD Caerwent and the groundwater contamination is therefore likely to extend a short distance beyond the site before being diluted to concentrations below the DWS.

The bioavailable fraction of copper in BH130 slightly exceeded EQS but due to the way the bioavailable fraction is calculated this was lower than bioavailable copper concentrations in any of the up-gradient wells including those in the FWA. However, the dissolved copper concentration was higher in three of the FWA wells and substantially higher in the settlement pond, indicating that the copper contamination is likely to derive from the FWA.

6.7.4 Summary of Water Quality Standards Exceedances in Groundwater

Table 6.9 summarises the exceedances of EQS and DWS recorded in the groundwater monitoring wells in the current study and also illustrates the scale of the exceedances.

Table 6.9: Summary of Water Quality Exceedances for Groundwaters Sampled 13th and 14th April 2016 (scale of exceedances colour coded – see note)

	COD mg O_2/L [1]	Ammoniacal Nitrogen **mg/L**	Copper (bioavailable) **µg/L**	Iron (dissolved) **µg/L**	Mercury (dissolved) **µg/L**	Manganese (dissolved) **µg/L**	Manganese (bioavailable) **µg/L**
EQS	**30** [1]	0.3	1	1000	0.07	-	123
DWS	**30** [1]	0.39	-	200	1	50	-
Groundwater Monitoring Locations Up-Gradient of FWA							
BH103	19	0.42	0.24	3600	0.05	1200	97
Groundwater Monitoring Locations at or near FWA							
BH102	53	2.7	0.07	4600	<0.05	1800	621
BH7	8.7	0.61	0.16	1100	<0.05	690	217

	COD mg O_2/L [1]	Ammoniacal Nitrogen mg/L	Copper (bioavailable) µg/L	Iron (dissolved) µg/L	Mercury (dissolved) µg/L	Manganese (dissolved) µg/L	Manganese (bioavailable) µg/L
BH104	7.8	0.11	0.56	36	<0.05	4.7	1.5
BH105	7.2	0.05	0.55	98	0.08	0.7	0.3
BH105A	50	0.05	0.69	60	0.07	2.3	0.9
Groundwater Monitoring Locations Down-Gradient of FWA							
BH106	7.5	0.06	0.07	2700	<0.05	220	125
BH106A	29	0.29	0.24	2900	0.1	4	1.8
BH107	10	0.14	0.1	1500	<0.05	440	77
BH130	5.1	0.04	1.33	7	0.08	0.8	0.4

Notes: [1] Not an EQS – screening value is from the repealed Surface Water Directive (Reference 6)

[2] The scale of exceedances has been illustrated by shading of cells in the table,
RED = >10 x EQS; YELLOW >5 x EQS; GREY = no exceedance of EQS

The table shows the most significant EQS exceedances occurred in the FWA at BH102 and relate to ammoniacal nitrogen and manganese contamination. These contaminant concentrations decreased in the downgradient wells where they fell to below EQS except at BH106 where there was a marginal exceedance for bioavailable manganese. Other marginal exceedances of EQS were also detected for mercury and bioavailable copper in perimeter wells. These marginal exceedances do not show any significant risk to off-site surface water features from groundwater baseflow.

DWS were substantially exceeded for iron and manganese and to a lesser extent for ammoniacal nitrogen in boreholes at the FWA. The iron and manganese contamination is also detectable above DWS in the downgradient wells at BH107, BH106 and BH106A (for iron only) and likely extends a small distance beyond the site boundary.

It is likely that the iron and manganese contamination is due in part to background geology as discussed in Section 6.8.

6.8 Influence of Background Geology on Water Quality

Some of the metal content observed in groundwater and to a lesser extent in surface water, is likely to be due to background geology. The South Wales Limestone has systems of richly mineralized solution-cavities along fracture-zones that commonly contain haematite (iron oxide) accompanied in some localities by goethite (iron hydroxide), quartz (silicon oxide), dolomite (magnesium carbonate), calcite (calcium carbonate) and barite (barium sulphate) (Reference 5).

The maximum concentrations of iron and manganese in groundwater are between two and three times the concentrations measured in surface water within the FWA. SW101 and SW202 would be expected to have far higher concentrations of leachate, as demonstrated by the higher ammoniacal nitrogen, BOD, COD and EC concentrations here. Similarly dissolved mercury concentrations are higher in the down-gradient perimeter wells than in the wells closest to the source of leachate within the FWA.

The elevated metal concentrations are not considered a reliable indicator of leachate migration to the site perimeter and it is more likely than not that leachate contamination is reducing in strength and extent.

7. Conclusions

CTL has undertaken waste treatment trials on the green wastes and confirmed that in its opinion all of the waste mounds can be effectively treated and recovered as topsoil, albeit with minor residual waste plastics. Approximately 220 m^3 of topsoil had been recovered from the waste at the time of the walkover survey in April 2016. Blending with other soils has not been necessary and only a minor amount of residual waste (mainly plastics) is produced as a by-product of the treatment process. This residual waste will not be disposed of by CTL and DIO's site management team have measures in place to collect and dispose of it. CTL has stated that the finished topsoil they are producing has been tested and found to comply with BS3882.

The green wastes need to be dried before being screened and this effectively limits the treatment to the drier summer months. The market demand for the material will also be a factor in the overall length of time it takes to fully treat all of the wastes, since CTL are not being paid to treat the wastes and their costs are reimbursed only by selling the finished topsoil. CTL has estimated that recovery of the wastes could take "a few years" to complete.

Although the FWA is now better organised and housekeeping is visibly improved since CTL took over the site, the green wastes continue to produce leachate. There is no formal or effective containment of leachate and it continues to soak to ground or to flow toward the Cas Troggy in the site drainage ditches.

To date there has been a limited amount of disturbance of the wastes which is likely limiting the generation of leachate. Disturbance of the waste could increase during the recovery process if works are not effectively managed. During the site walkover visit CTL appeared to be managing this risk by working with small amounts of waste at a time.

Monitoring in groundwater wells has shown the key leachate indicator compound, ammoniacal nitrogen is present at a concentration 9 times EQS and 7 times DWS in the well nearest the waste mounds in the FWA. Metal concentrations are also elevated in wells nearest the waste mounds but there is evidence that the metal contamination derives partly from the background geology.

Surface water in the drainage ditches is shown to be locally impacted near the FWA. But the drainage ditch ran dry on the MOD Caerwent site part way to the Cas Troggy and the sample from within MOD Caerwent nearest to the Cas Troggy did not exceed EQS. Despite blockages apparent in the drainage ditches, it is likely that flows in the ditches will reach the Cas Troggy in extended periods of heavy rainfall. In such periods the leachate contamination is likely to be substantially diluted. It is therefore possible that no detectable impact to the Cas Troggy would occur at any part of the year. In addition, as the waste mass reduces during the life of the treatment process, the volume of leachate produced will also reduce and contaminant loadings will therefore decrease over time.

The high levels of cadmium previously detected in the surface water drainage have not been recorded in the current monitoring round.

8. Recommendations

Monitoring shows that risks to the aquifer within MOD Caerwent remain high from leachate derived from the green waste. But, risks to wider aquifer remain low. Some metal contamination is evident in perimeter wells but this is unlikely to derive from leachate from the FWA. In the absence of any leachate control measures at the FWA and with continued leachate generation from the wastes it would be prudent to continue with environmental monitoring to determine whether risks to the principal aquifer and off-site stream reduce over time or whether remedial measures are needed.

It is recommended that controls are put in place to attempt to limit leachate generation or to prevent leachate from reaching groundwater and the surface water ditches. This might involve placing the wastes under cover, either by sheeting over or by moving into buildings or collection and off-site treatment of leachates. The latter option would likely involve a substantial cost and the former option is therefore likely to be more practical.

In addition, quarterly monitoring of surface water and biannual (6 monthly) monitoring of groundwater is recommended to assess changes in water quality whilst wastes are being processed at the FWA.

The recommended scope of monitoring round is as follows:

- Biannual sampling of 11 groundwater wells comprising: 1 up-gradient location, 6 locations in the former Wormtech area and 4 down-gradient locations;
- Quarterly sampling of surface water at 7 locations comprising:
  - SW101 and SW202 in the FWA;
  - SW105 or SW201 in the area between the FWA and the site perimeter; and
  - SW102, Field Culvert, SW103 and SW104 at the site perimeter/Cas Troggy.

  Surface water risks to the Cas Troggy only exist in periods of extended wet weather when the drainage channels flow all the way to the culvert. Where possible, monitoring would be timed to coincide with these high flow events in order to increase the relevance to the surface water assessment.
- Analysis would be restricted to the key leachate indicator compounds:
  - Chloride, ammoniacal nitrogen, pH, EC, BOD and alkalinity.
- Interpretative reporting after each monitoring round in a letter format issued by email.

If controls are implemented by CTL or the MOD to limit leachate release at the site, it should be possible to reduce the frequency of monitoring to a bi-annual basis.

9. References

1. Jacobs. June 2015. DTE Caerwent: Former Wormtech Area: Land Quality Assessment Report.

2. Enviros Consulting. January 2006. ATE Caerwent Training Area Land Quality Assessment: Phase One Desk Study – Land Quality Assessment Report. Project No: 12813.

3. European Commission. Drinking Water Legislation: The Directive Overview. Last updated 22/02/2016.

4. The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015

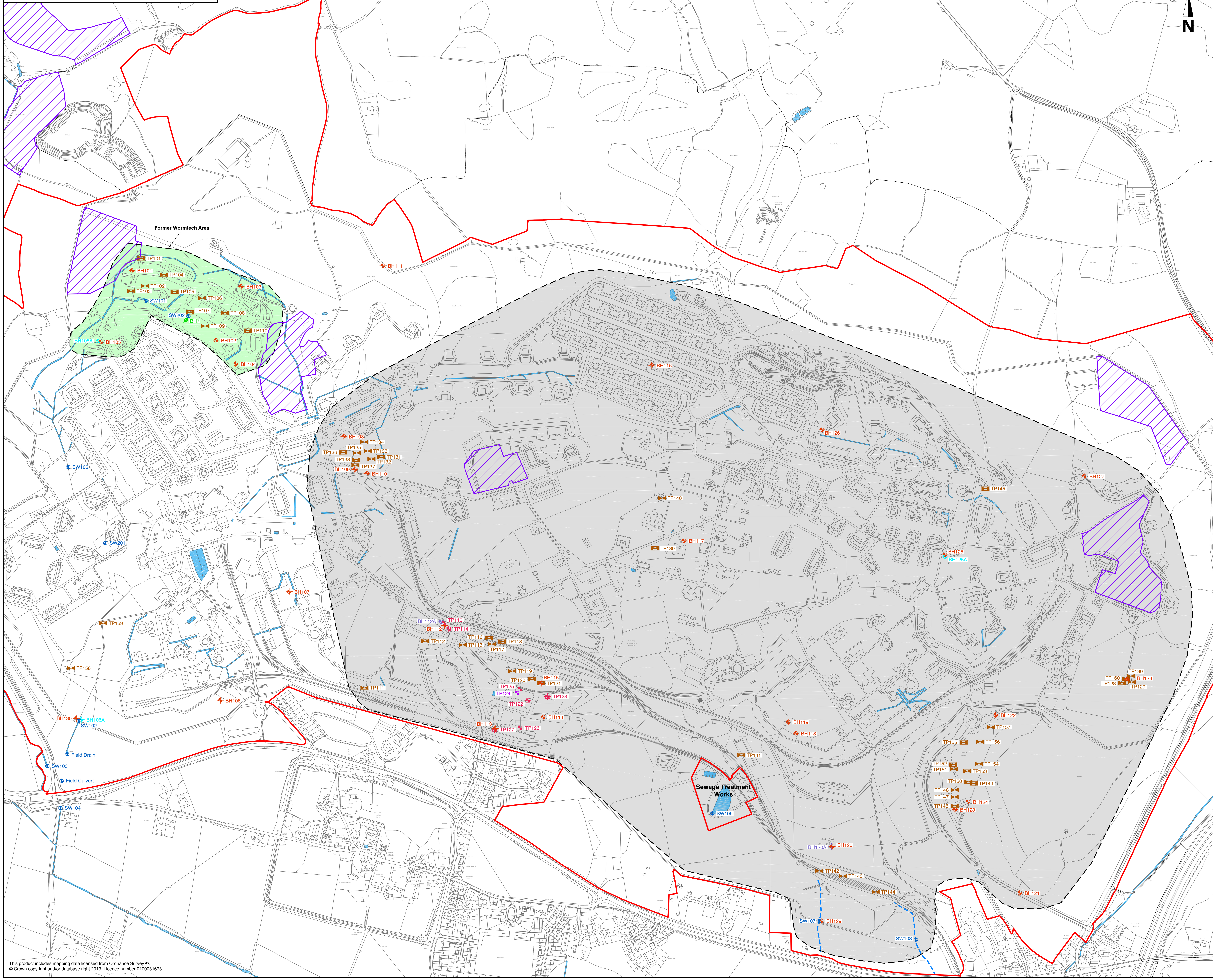
5. National Museum Wales Mineralogy of Wales Database accessed July 2016 at: https://museum.wales/mineralogy-of-wales/database/?mineral=269

6. Council of the European Union June 1975. Council Directive concerning the quality required of surface water intended for the abstraction of drinking water in the Member States (Surface Water Directive). Council Directive 75/440/EEC. (Repealed December 2007)

FIGURES

Drawing number / Rev

B41600AB/CWA/0001_0



KEY:

- Former Wormtech Area Assessed in Current Report
- Exploratory Holes in This Area Not Assessment in Current Report
- Rotary Boreholes with Standpipes Installed in Rock Aquifer
- Cable Percussive Boreholes with Shallow Standpipe Installation
- Cable Percussive Boreholes without Standpipe
- Window Sample Borehole with Shallow Standpipe Installation
- Window Sample Borehole without Standpipe
- Mechanical Trial Pit Excavation
- Surface Water Monitoring Point
- Existing Standpipes in Rock Aquifer
- Seasonal Surface Water Feature
- Sites of Special Scientific Interest (SSSI)

Rev	Rev. Date	Purpose of revision	Drawn	Checkd	Rev'd	Apprv'd
0	29/04/16	Preliminary	HR	EP	AJ	-

JACOBS

Jacobs House, Shrewsbury Business Park, Sitka Drive, Shrewsbury SY2 6LG
Tel:+44(0)1743 284800
www.jacobs.com

Client

Defence Infrastructure Organisation

Project

DTE CAERWENT -
FORMER WORMTECH AREA
PHASE 2 LAND QUALITY ASSESSMENT

Drawing title

SITE LAYOUT AND ENVIRONMENTAL MONITORING LOCATIONS (FIGURE 1)

Drawing status

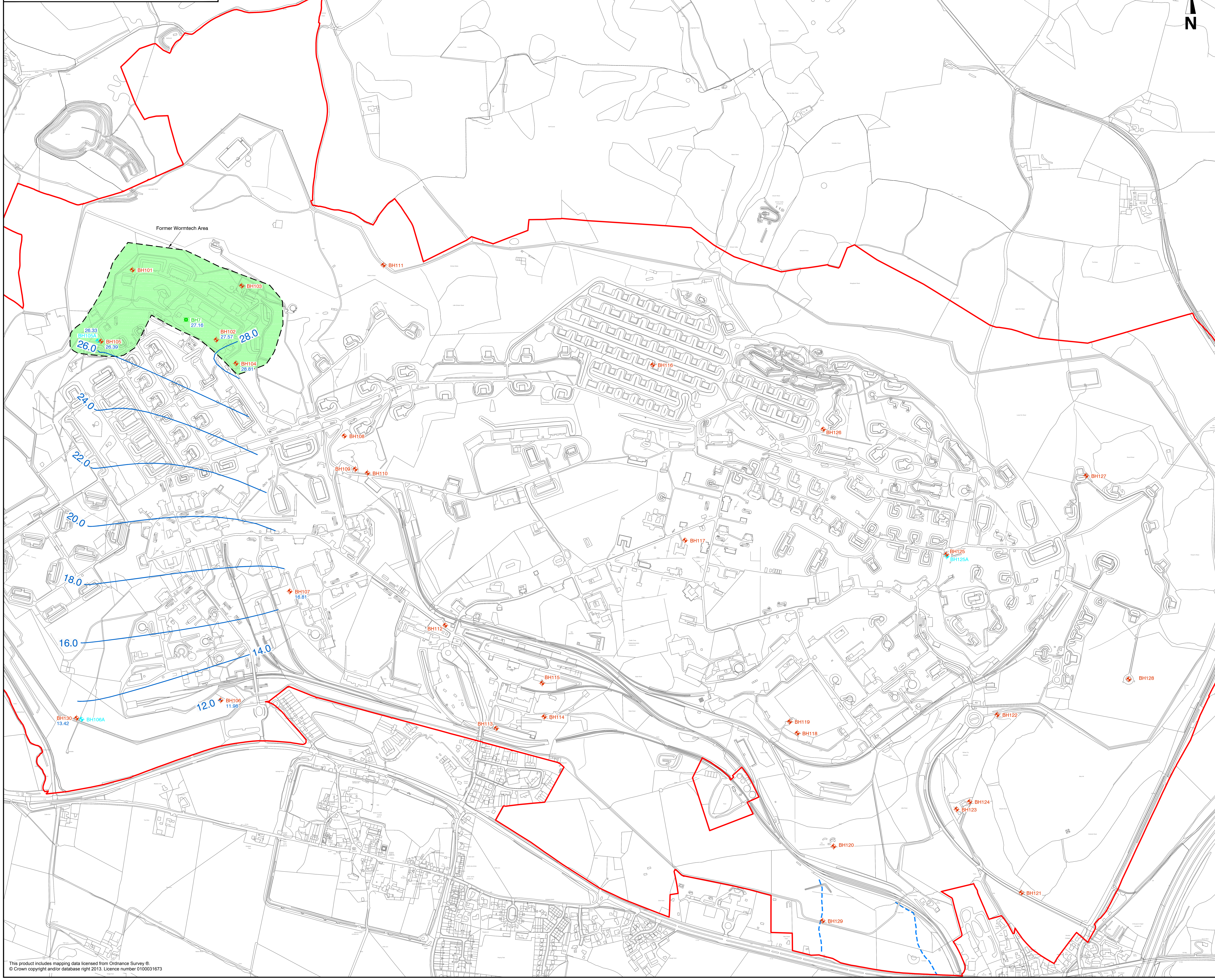
FINAL

Scale	1:5,000 @ A1	DO NOT SCALE
Jacobs No.	B41600AB	
Client no.	-	

Drawing number	Rev
B41600AB/CWA/0001	0

Drawing number / Rev

B41600AB/CWA/0002_0



This product includes mapping data licensed from Ordnance Survey ®.

KEY:

- Rotary Boreholes with Standpipes Installed in Rock Aquifer
- Cable Percussive Boreholes with Shallow Standpipe Installation
- Existing Standpipes in Rock Aquifer
- Seasonal Surface Water Feature
- 31.28 Groundwater Height (m AOD) - April 2016
- Groundwater Contours (m AOD)

NOTES:

Groundwater levels from boreholes with anomalous groundwater readings have been omitted from the plan. These locations are generally where water levels were very close to the base of the installation.

The aquifer at Caerwent is heterogeneous and the contour plan has been prepared to provide an indication of the flow direction and likely hydraulic gradient. Water levels can vary markedly between boreholes located close to one another and where apparent anomalies have been identified these have been excluded from the map. Anomalous locations are often where water levels are close to the base of the installation.

Rev	Rev. Date	Purpose of revision	Drawn	Checkd	Rev'd	Apprv'd
0	29/04/16	Preliminary	HR	EP	AJ	AJ

JACOBS

Jacobs House, Shrewsbury Business Park, Sitka Drive, Shrewsbury SY2 6LG
Tel:+44(0)1743 284800
www.jacobs.com

Client

Defence Infrastructure Organisation

Project

DTE CAERWENT -
FORMER WORMTECH AREA
PHASE 2 LAND QUALITY ASSESSMENT

Drawing title

INDICATIVE GROUNDWATER CONTOUR PLAN - APRIL 2016

(FIGURE 2)

Drawing status	FINAL	
Scale	1:5,000 @ A1	DO NOT SCALE
Jacobs No.	B41600AB	
Client no.	-	
Drawing number	B41600AB/CWA/0002	Rev 0

Appendix A. Laboratory Analysis Certificates

Anthony John
Jacobs
10 Tynant Court
Morganstown
Cardiff
CF15 8LW

e: anthony.john@jacobs.com

i2 Analytical Ltd.
7 Woodshots Meadow,
Croxley Green
Business Park,
Watford,
Herts,
WD18 8YS

t: 01923 225404
f: 01923 237404
e: reception@i2analytical.com

Analytical Report Number : 16-15356

Project / Site name:	Caerwent	**Samples received on:**	14/04/2016
Your job number:	B41600AB	**Samples instructed on:**	14/04/2016
Your order number:		**Analysis completed by:**	22/04/2016
Report Issue Number:	1	**Report issued on:**	22/04/2016
Samples Analysed:	9 water samples		

Signed:

Rexona Rahman
Reporting Manager
For & on behalf of i2 Analytical Ltd.

Signed:

Emma Winter
Assistant Reporting Manager
For & on behalf of i2 Analytical Ltd.

Standard Geotechnical, Asbestos and Chemical Testing Laboratory located at: ul. Pionierów 39, 41 -711 Ruda Śląska, Poland.

Accredited tests are defined within the report, opinions and interpretations expressed herein are outside the scope of accreditation.

Standard sample disposal times, unless otherwise agreed with the laboratory, are :

soils - 4 weeks from reporting
leachates - 2 weeks from reporting
waters - 2 weeks from reporting
asbestos - 6 months from reporting

Excel copies of reports are only valid when accompanied by this PDF certificate.

Analytical Report Number: 16-15356

Project / Site name: Caerwent

Lab Sample Number				560735	560736	560737	560738	560739
Sample Reference				BH103	SW104	SW103	SW105	SW201
Sample Number				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Depth (m)				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Date Sampled				13/04/2016	13/04/2016	13/04/2016	13/04/2016	13/04/2016
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Water Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
General Inorganics								
pH	pH Units	N/A	ISO 17025	7.8	8.1	8.2	8.1	8.7
Chloride	mg/l	0.15	ISO 17025	27	14	14	19	19
Ammoniacal Nitrogen as N	µg/l	15	ISO 17025	420	140	54	1200	210
Dissolved Organic Carbon (DOC)	mg/l	0.1	NONE	1.14	1.31	1.10	2.84	3.50
Chemical Oxygen Demand (Total)	mg/l	2	ISO 17025	19	5.2	4.2	6.3	7.3
BOD (Biochemical Oxygen Demand)	mg/l	1	ISO 17025	< 1.0	1.2	1.2	1.1	2.2
Hardness - Total	mgCaCO3/l	1	ISO 17025	-	-	123	-	-
Heavy Metals / Metalloids								
Arsenic (dissolved)	µg/l	0.15	ISO 17025	1.44	0.39	0.27	0.38	0.54
Boron (dissolved)	µg/l	10	ISO 17025	78	17	18	33	32
Cadmium (dissolved)	µg/l	0.02	ISO 17025	< 0.02	< 0.02	< 0.02	0.02	< 0.02
Chromium (hexavalent)	µg/l	5	ISO 17025	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Chromium (dissolved)	µg/l	0.2	ISO 17025	0.6	0.3	0.4	0.3	0.3
Copper (dissolved)	µg/l	0.5	ISO 17025	1.0	3.1	2.8	4.4	4.7
Lead (dissolved)	µg/l	0.2	ISO 17025	< 0.2	< 0.2	< 0.2	< 0.2	0.2
Mercury (dissolved)	µg/l	0.05	ISO 17025	0.05	< 0.05	< 0.05	< 0.05	< 0.05
Nickel (dissolved)	µg/l	0.5	ISO 17025	1.9	2.4	2.1	3.6	2.8
Zinc (dissolved)	µg/l	0.5	ISO 17025	1.3	1.5	1.0	3.3	3.4
Calcium (dissolved)	mg/l	0.012	ISO 17025	110	32	32	67	56
Magnesium (dissolved)	mg/l	0.005	ISO 17025	-	-	10	-	-
Chromium (total)	µg/l	0.2	ISO 17025	0.9	0.4	0.5	0.4	0.3
Iron (total)	mg/l	0.004	ISO 17025	3.6	0.20	0.090	0.039	0.046
Manganese (total)	µg/l	0.05	ISO 17025	1200	8.9	3.8	18	16

U/S = Unsuitable Sample   I/S = Insufficient Sample

Analytical Report Number: 16-15356

Project / Site name: Caerwent

Lab Sample Number				560740	560741	560742	560743	
Sample Reference				SW101	SW202	BH107	BH106	
Sample Number				None Supplied	None Supplied	None Supplied	None Supplied	
Depth (m)				None Supplied	None Supplied	None Supplied	None Supplied	
Date Sampled				13/04/2016	13/04/2016	13/04/2016	13/04/2016	
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	
Analytical Parameter (Water Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
General Inorganics								
pH	pH Units	N/A	ISO 17025	8.1	8.2	7.9	7.9	
Chloride	mg/l	0.15	ISO 17025	230	75	9.6	8.7	
Ammoniacal Nitrogen as N	µg/l	15	ISO 17025	22000	6500	140	64	
Dissolved Organic Carbon (DOC)	mg/l	0.1	NONE	93.6	57.6	1.71	2.02	
Chemical Oxygen Demand (Total)	mg/l	2	ISO 17025	300	210	10	7.5	
BOD (Biochemical Oxygen Demand)	mg/l	1	ISO 17025	12	9.6	1.3	1.0	
Hardness - Total	mgCaCO3/l	1	ISO 17025	-	-	-	-	
Heavy Metals / Metalloids								
Arsenic (dissolved)	µg/l	0.15	ISO 17025	4.95	5.37	0.35	0.31	
Boron (dissolved)	µg/l	10	ISO 17025	220	120	60	18	
Cadmium (dissolved)	µg/l	0.02	ISO 17025	0.08	0.10	< 0.02	0.04	
Chromium (hexavalent)	µg/l	5	ISO 17025	< 5.0	< 5.0	< 5.0	< 5.0	
Chromium (dissolved)	µg/l	0.2	ISO 17025	1.2	2.4	1.0	0.4	
Copper (dissolved)	µg/l	0.5	ISO 17025	14	23	0.7	< 0.5	
Lead (dissolved)	µg/l	0.2	ISO 17025	1.5	4.3	0.2	< 0.2	
Mercury (dissolved)	µg/l	0.05	ISO 17025	0.08	0.06	< 0.05	< 0.05	
Nickel (dissolved)	µg/l	0.5	ISO 17025	25	14	1.9	2.3	
Zinc (dissolved)	µg/l	0.5	ISO 17025	27	24	2.2	3.6	
Calcium (dissolved)	mg/l	0.012	ISO 17025	160	59	75	56	
Magnesium (dissolved)	mg/l	0.005	ISO 17025	-	-	-	-	
Chromium (total)	µg/l	0.2	ISO 17025	1.4	2.6	1.5	1.2	
Iron (total)	mg/l	0.004	ISO 17025	1.4	1.8	1.5	2.7	
Manganese (total)	µg/l	0.05	ISO 17025	830	380	440	220	

U/S = Unsuitable Sample   I/S = Insufficient Sample

Analytical Report Number : 16-15356

Project / Site name: Caerwent

Water matrix abbreviations: Surface Water (SW) Potable Water (PW) Ground Water (GW)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Ammoniacal Nitrogen as N in water	Determination of Ammonium/Ammonia/Ammoniacal Nitrogen by the colorimetric salicylate/nitroprusside method. Accredited matrices SW, GW, PW.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton	L082-PL	W	ISO 17025
Biological oxygen demand of water	Determination of biochemical oxygen demand in water (5 days). Accredited matrices: SW, PW, GW.	In-house method based on standard method 5210B. Samples received > 24 hrs after sampling, data may not be valid and should be interpreted with care.	L086-PL	W	ISO 17025
Boron in water	Determination of boron in water by acidification followed by ICP-OES. Accredited matrices: SW PW GW	In-house method based on MEWAM	L039-PL	W	ISO 17025
Chemical Oxygen Demand in Water (Total)	Determination of total COD in water by reflux oxidation with acidified K2Cr2O7 followed by colorimetry. Accredited matrices: SW, PW, GW.	HACH DR/890 Colorimeter Procedures Manual (48470-22) (Ref 0170.2)	L065-PL	W	ISO 17025
Chloride in water	Determination of Chloride colorimetrically by discrete analyser.	In house based on MEWAM Method ISBN 0117516260. Accredited matrices: SW, PW, GW.	L082 B	W	ISO 17025
Dissolved Organic Carbon in water	Determination of dissolved inorganic carbon in water by TOC/DOC NDIR Analyser.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton	L037-PL	W	NONE
Hexavalent chromium in water	Determination of hexavalent chromium in water by acidification, addition of 1,5 diphenylcarbazide followed by colorimetry.	In-house method by continuous flow analyser. Accredited Matrices SW, GW, PW.	L080-PL	W	ISO 17025
Metals in water by ICP-MS (dissolved)	Determination of metals in water by acidification followed by ICP-MS. Accredited Matrices: SW, GW, PW except B=SW,GW, Hg=SW,PW, Al=SW,PW.	In-house method based on USEPA Method 6020 & 200.8 "for the determination of trace elements in water by ICP-MS.	L012-PL	W	ISO 17025
Metals in water by ICP-OES (dissolved)	Determination of metals in water by acidification followed by ICP-OES. Accredited Matrices SW, GW, PW.	In-house method based on MEWAM 2006 Methods for the Determination of Metals in Soil.	L039-PL	W	ISO 17025
Metals in water by ICP-OES (total)	Determination of metals in water by acidification followed by ICP-OES. Accredited matrices: SW PW GW	In-house method based on MEWAM 2006 Methods for the Determination of Metals in Soil.	L039-PL	W	ISO 17025
pH in water	Determination of pH in water by electrometric measurement. Accredited matrices: SW PW GW	In-house method based on BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L005-PL	W	ISO 17025
Total Hardness of water	Determination of hardness in waters by calculation from calcium and magnesium. Accredited Matrices SW, GW, PW.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton	L045-PL	W	ISO 17025

For method numbers ending in 'UK' analysis have been carried out in our laboratory in the United Kingdom.
For method numbers ending in 'PL' analysis have been carried out in our laboratory in Poland.
Soil analytical results are expressed on a dry weight basis. Where analysis is carried out on as-received the results obtained are multiplied by a moisture correction factor that is determined gravimetrically using the moisture content which is carried out at a maximum of 30oC.

Anthony John
Jacobs
10 Tynant Court
Morganstown
Cardiff
CF15 8LW

e: anthony.john@jacobs.com

i2 Analytical Ltd.
7 Woodshots Meadow,
Croxley Green
Business Park,
Watford,
Herts,
WD18 8YS

t: 01923 225404
f: 01923 237404
e: reception@i2analytical.com

Analytical Report Number : 16-15457

Project / Site name:	Caerwent	**Samples received on:**	15/04/2016
Your job number:	B41600AB	**Samples instructed on:**	15/04/2016
Your order number:		**Analysis completed by:**	22/04/2016
Report Issue Number:	1	**Report issued on:**	22/04/2016
Samples Analysed:	7 water samples		

Signed:

Rexona Rahman
Reporting Manager
For & on behalf of i2 Analytical Ltd.

Signed:

Emma Winter
Assistant Reporting Manager
For & on behalf of i2 Analytical Ltd.

Standard Geotechnical, Asbestos and Chemical Testing Laboratory located at: ul. Pionierów 39, 41 -711 Ruda Śląska, Poland.

Accredited tests are defined within the report, opinions and interpretations expressed herein are outside the scope of accreditation.

Standard sample disposal times, unless otherwise agreed with the laboratory, are :

soils - 4 weeks from reporting
leachates - 2 weeks from reporting
waters - 2 weeks from reporting
asbestos - 6 months from reporting

Excel copies of reports are only valid when accompanied by this PDF certificate.

Analytical Report Number: 16-15457

Project / Site name: Caerwent

Lab Sample Number				561439	561440	561441	561442	561443
Sample Reference				BH106A	BH130	BH105	BH105A	BH104
Sample Number				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Depth (m)				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Date Sampled				14/04/2016	14/04/2016	14/04/2016	14/04/2016	14/04/2016
Time Taken				1100	1120	1200	1220	1220
Analytical Parameter (Water Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
General Inorganics								
pH	pH Units	N/A	ISO 17025	7.8	7.9	8.0	7.7	7.6
Chloride	mg/l	0.15	ISO 17025	14	18	15	14	19
Ammoniacal Nitrogen as N	µg/l	15	ISO 17025	290	41	46	47	110
Dissolved Organic Carbon (DOC)	mg/l	0.1	NONE	1.21	0.57	0.73	0.83	1.76
Chemical Oxygen Demand (Total)	mg/l	2	ISO 17025	29	5.1	7.8	7.2	8.7
BOD (Biochemical Oxygen Demand)	mg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Heavy Metals / Metalloids								
Arsenic (dissolved)	µg/l	0.15	ISO 17025	0.17	< 0.15	0.18	0.18	0.22
Boron (dissolved)	µg/l	10	ISO 17025	21	19	21	23	34
Cadmium (dissolved)	µg/l	0.02	ISO 17025	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Chromium (hexavalent)	µg/l	5	ISO 17025	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Chromium (dissolved)	µg/l	0.2	ISO 17025	0.7	0.5	0.7	0.7	0.3
Copper (dissolved)	µg/l	0.5	ISO 17025	1.0	2.9	1.6	2.0	3.4
Lead (dissolved)	µg/l	0.2	ISO 17025	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Manganese (dissolved)	µg/l	0.05	ISO 17025	4.0	0.79	0.73	2.3	4.7
Mercury (dissolved)	µg/l	0.05	ISO 17025	0.10	0.08	0.08	0.07	< 0.05
Nickel (dissolved)	µg/l	0.5	ISO 17025	1.1	0.9	1.9	1.9	1.2
Zinc (dissolved)	µg/l	0.5	ISO 17025	1.0	2.0	2.8	1.9	2.4
Calcium (dissolved)	mg/l	0.012	ISO 17025	3.6	2.7	4.2	4.2	6.0
Chromium (total)	µg/l	0.2	ISO 17025	1.0	0.6	0.9	0.9	0.3
Iron (total)	mg/l	0.004	ISO 17025	2.9	0.007	0.098	0.060	0.036

U/S = Unsuitable Sample   I/S = Insufficient Sample

Analytical Report Number: 16-15457

Project / Site name: Caerwent

Lab Sample Number				561444	561445			
Sample Reference				BH102	BH7			
Sample Number				None Supplied	None Supplied			
Depth (m)				None Supplied	None Supplied			
Date Sampled				14/04/2016	14/04/2016			
Time Taken				1245	1315			
Analytical Parameter (Water Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
General Inorganics								
pH	pH Units	N/A	ISO 17025	7.7	7.5			
Chloride	mg/l	0.15	ISO 17025	180	190			
Ammoniacal Nitrogen as N	µg/l	15	ISO 17025	2700	610			
Dissolved Organic Carbon (DOC)	mg/l	0.1	NONE	17.2	14.6			
Chemical Oxygen Demand (Total)	mg/l	2	ISO 17025	53	50			
BOD (Biochemical Oxygen Demand)	mg/l	1	ISO 17025	< 1.0	1.5			
Heavy Metals / Metalloids								
Arsenic (dissolved)	µg/l	0.15	ISO 17025	0.64	0.84			
Boron (dissolved)	µg/l	10	ISO 17025	100	65			
Cadmium (dissolved)	µg/l	0.02	ISO 17025	< 0.02	0.04			
Chromium (hexavalent)	µg/l	5	ISO 17025	< 5.0	< 5.0			
Chromium (dissolved)	µg/l	0.2	ISO 17025	< 0.2	0.2			
Copper (dissolved)	µg/l	0.5	ISO 17025	3.0	7.2			
Lead (dissolved)	µg/l	0.2	ISO 17025	< 0.2	0.8			
Manganese (dissolved)	µg/l	0.05	ISO 17025	1800	690			
Mercury (dissolved)	µg/l	0.05	ISO 17025	< 0.05	< 0.05			
Nickel (dissolved)	µg/l	0.5	ISO 17025	16	11			
Zinc (dissolved)	µg/l	0.5	ISO 17025	2.4	4.7			
Calcium (dissolved)	mg/l	0.012	ISO 17025	10	10			
Chromium (total)	µg/l	0.2	ISO 17025	0.3	0.3			
Iron (total)	mg/l	0.004	ISO 17025	4.6	1.1			

U/S = Unsuitable Sample   I/S = Insufficient Sample

Analytical Report Number : 16-15457

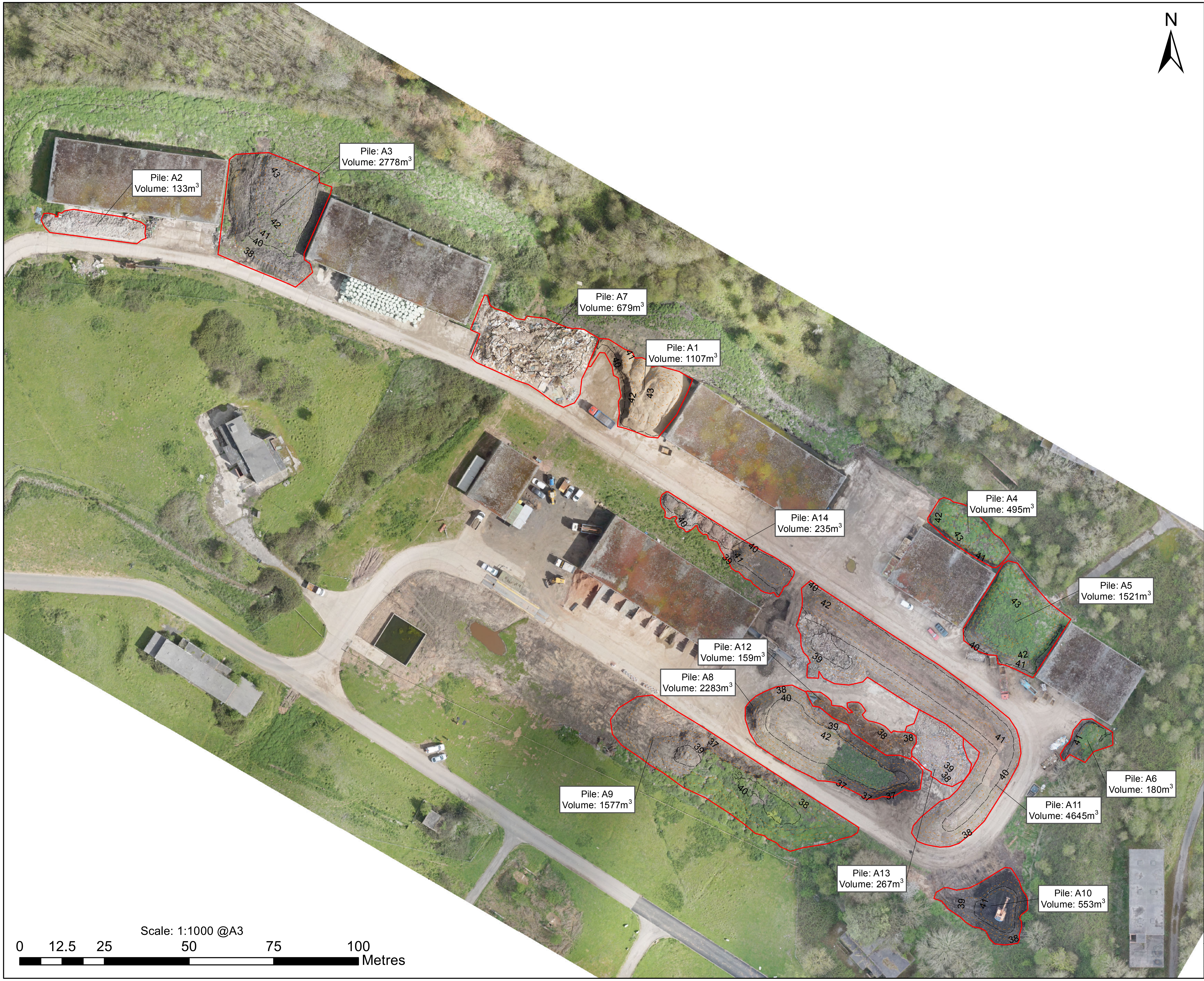
Project / Site name: Caerwent

Water matrix abbreviations: Surface Water (SW) Potable Water (PW) Ground Water (GW)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Ammoniacal Nitrogen as N in water	Determination of Ammonium/Ammonia/Ammoniacal Nitrogen by the colorimetric salicylate/nitroprusside method. Accredited matrices SW, GW, PW.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton	L082-PL	W	ISO 17025
Biological oxygen demand of water	Determination of biochemical oxygen demand in water (5 days). Accredited matrices: SW, PW, GW.	In-house method based on standard method 5210B. Samples received > 24 hrs after sampling, data may not be valid and should be interpreted with care.	L086-PL	W	ISO 17025
Boron in water	Determination of boron in water by acidification followed by ICP-OES. Accredited matrices: SW PW GW	In-house method based on MEWAM	L039-PL	W	ISO 17025
Chemical Oxygen Demand in Water (Total)	Determination of total COD in water by reflux oxidation with acidified $K_2Cr_2O_7$ followed by colorimetry. Accredited matrices: SW, PW, GW.	HACH DR/890 Colorimeter Procedures Manual (48470-22) (Ref 0170.2)	L065-PL	W	ISO 17025
Chloride in water	Determination of Chloride colorimetrically by discrete analyser.	In house based on MEWAM Method ISBN 0117516260. Accredited matrices: SW, PW, GW.	L082 B	W	ISO 17025
Dissolved Organic Carbon in water	Determination of dissolved inorganic carbon in water by TOC/DOC NDIR Analyser.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton	L037-PL	W	NONE
Hexavalent chromium in water	Determination of hexavalent chromium in water by acidification, addition of 1,5 diphenylcarbazide followed by colorimetry.	In-house method by continuous flow analyser. Accredited Matrices SW, GW, PW.	L080-PL	W	ISO 17025
Metals in water by ICP-MS (dissolved)	Determination of metals in water by acidification followed by ICP-MS. Accredited Matrices: SW, GW, PW except B=SW,GW, Hg=SW,PW, Al=SW,PW.	In-house method based on USEPA Method 6020 & 200.8 "for the determination of trace elements in water by ICP-MS.	L012-PL	W	ISO 17025
Metals in water by ICP-OES (dissolved)	Determination of metals in water by acidification followed by ICP-OES. Accredited Matrices SW, GW, PW.	In-house method based on MEWAM 2006 Methods for the Determination of Metals in Soil.	L039-PL	W	ISO 17025
Metals in water by ICP-OES (total)	Determination of metals in water by acidification followed by ICP-OES. Accredited matrices: SW PW GW	In-house method based on MEWAM 2006 Methods for the Determination of Metals in Soil.	L039-PL	W	ISO 17025
pH in water	Determination of pH in water by electrometric measurement. Accredited matrices: SW PW GW	In-house method based on BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L005-PL	W	ISO 17025

For method numbers ending in 'UK' analysis have been carried out in our laboratory in the United Kingdom.
For method numbers ending in 'PL' analysis have been carried out in our laboratory in Poland.
Soil analytical results are expressed on a dry weight basis. Where analysis is carried out on as-received the results obtained are multiplied by a moisture correction factor that is determined gravimetrically using the moisture content which is carried out at a maximum of 30oC.

Appendix B. Volumetric Survey of Waste Stockpiles



Caerwent Training Area

UAV Stockpile Survey

27th April 2016

Drawn: PR 02/05/2016

JACOBS

IMS INTELLIGENT MAPPING SOLUTIONS

(red outline)	Stockpiles
Date Flown	27th April 2016
UAV Serial	F8
Imagery Type	Colour
Camera Type	ILCE 7R
Focal Length	35mm
Camera Resolution	7360 x 4912
Altitude	120m
GSD	1.78cm
GCPs Used	7
Number of Images	128
Number of Flights	2
Site Area (Ha)	9 ha
Coordinate System	BNG 27700
Centre Point	346474.5, 192075.2
File Name	Caerwent_270416

Appendix 5: Jacobs Land Quality Assessment Report – LQA2 2019