HORIZON
NUCLEAR POWER

WYLFA NEWYDD

ENERGY WORKING FOR BRITAIN

Wylfa Newydd Project

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Construction H1 Assessment

Horizon Nuclear Power Ltd

Jacobs Ref: 60PO8083/HYD/REP/001001

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Project manager:	Rob Bromley
Author:	Ian Coleman
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Jacobs U.K. Limited

1180 Eskdale Road
Winnersh, Wokingham
Reading RG41 5TU
United Kingdom
T +44 (0)118 946 7000
F +44 (0)118 946 7001
www.jacobs.com

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0	26/07/17	Issue of preliminary assessment to Horizon for comments	IAC, EC	SLH/MWB	
0.2	11/08/17	Address Horizon review comments.	IAC	SLH/MWB	RB
1.0	12/12/17	Update of H1 assessment [based on: H1 Construction Assessment Rev 1 stage 2.2.docx (August 2017)]	IAC	MR	RB
1.0	01/02/18	Update to address HNP comments and revised drainage	MWB	SH/MR	RB
1.0	13/02/18	Update to address HNP and NRW comments	MWB	SH/MR	RB
1.0	28/02/18	Update following modelling	ILE/IC	RW	RB
1.0	12/03/18	Update to address further HNP comments	MWB	SH	RB

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Executive Summary

As part Horizon Nuclear Power (Wylfa) Ltd's permit application for water discharges associated with construction works, an assessment of impacts on the receiving waters is required, following H1 Horizontal Guidance. This is required for discharges to both freshwater and to the marine environment and includes those discharges from construction phase drainage, groundwater dewatering and sewage discharges associated with the construction works.

This report compiles and presents the data sources that have been used in the H1 assessment including sampling and leaching test results which are used for determining potential concentrations for discharges from the Wylfa Newydd Development Area. The report then presents the results from the H1 assessment to determine the predicted effects so that Natural Resources Wales (NRW) can identify assessment criteria for the receiving environments.

The potential effects of substances are assessed in two phases: a screening phase and, where required, a modelling phase. In each phase, substances are assessed to determine if they are "liable to cause pollution". Those which are liable to cause pollution, in terms of potentially exceeding Environmental Quality Standards (EQSs), will need to be controlled in the permit.

The screening phase of the assessment has a number of 'tests' which increase progressively in complexity. If a substance "fails" these tests, it passes through to the next phase, the modelling assessment. If the screening tests are "passed", the substance is classed as insignificant and is screened out. The screening phase uses raw data, where available, as these represent the worst case scenario and minimise the time spent assessing substances which are not liable to cause pollution. For subsequent modelling, "cleaned up" data are used.

For freshwater discharges, the screening tests identified that orthophosphate, bioavailable copper, chromium, iron, bioavailable lead, dissolved lead, nitrate, bioavailable zinc and anionic polyelectrolyte required further modelling for one or more of the discharge points. This further modelling, undertaken using the River Quality Planning (RQP) model, identified that potentially for orthophosphate the annual average EQS (AA EQS) is exceeded in all catchments. However, in some cases the upstream orthophosphate concentration already exceeds the EQS. No other annual average EQSs are predicted to be exceeded. The RQP modelling also predicts that the downstream quality may deteriorate by more than 10% of the AA EQS for orthophosphate, bioavailable copper, iron and bioavailable lead in the Tre'r Gof SSSI drains; orthophosphate and bioavailable lead in Nant Caerdegog Isaf; and orthophosphate at the Tre'r Gof Site of Special Scientific Interest (SSSI) discharge. For exceedances of short-term EQSs, dissolved lead showed as being potentially significant for the discharge of surface water runoff to the Tre'r Gof SSSI drains.

With respect to the marine environment, the initial screening of data identified dissolved copper, lead, nickel and zinc as requiring further assessment by modelling. This further modelling was undertaken using a marine hydrodynamic model. Modelling predicted all concentrations of dissolved nickel would be below the AA EQS. For copper, zinc and lead the predicted maximum concentrations were all above the relevant AA EQSs. However, the predicted mixing zones in the marine environment are relatively small and are considered precautionary. The substances predicted to be above the AA EQS would not remain above the AA EQS in the long-term as soil stripping, earthworks, dewatering and mound creation would be carried out in different areas at different times across the Wylfa Newydd Development Area. In addition, mounds would be reseeded when left dormant for more than 60 days, or when work is complete, thereby reducing the leaching of substances from the soil.

1. Introduction

1.1 Purpose of this Report

As part of the permit application for water discharges associated with construction works, an assessment of impacts on the receiving waters is required, following H1 Horizontal Guidance (see chapter 2). Horizon Nuclear Power (Wylfa) Ltd (Horizon) has instructed Jacobs UK Limited (Jacobs) to prepare a report detailing the work undertaken to determine the effects of surface water discharges associated with construction works for development of the Wylfa Newydd Power Station on the receiving water environment.

The development of this work has been informed by a number of meetings with Natural Resources Wales (NRW) between 2015 and 2018.

1.2 Aims of this Report

The aims of the work are to:

- compile and present the data sources that are being used in the H1 surface water assessment including sampling and leaching test results which are used for determining potential concentrations for discharges from the site; and
- to undertake and present results from the H1 assessment to determine the predicted effects so that NRW can identify assessment criteria for the receiving environments.

2. Guidance Documents

2.1 Environment Agency Environmental Permit guidance

The NRW's website [RD1] accessed 15 May 2017 shows that guidance on undertaking surface water impact assessments published by the Environment Agency on the UK Government's website [RD2] is to be used for undertaking H1 impact assessments. The assessment described in this report primarily follows this web-based guidance, which is referred to as "the H1 guidance" (see section 3). Additional guidance provided in NRW document EPR 7.01 [RD3] has also been considered.

3. The H1 Methodology

The assessment presented in this report has been undertaken using spreadsheets based on the Environment Agency's H1 software tool and equations presented in the H1 guidance. The assessment has been made to evaluate the effect of discharges from the drainage works associated with the construction of the Power Station.

The methodology presented in the H1 guidance is used to determine how to permit discharges of hazardous pollutants to surface waters (hazardous pollutants include priority hazardous substances, priority substances, specific pollutants and substances with operational Environmental Quality Standards (EQSs)). Where an EQS is not available then other appropriate values have been applied, as described in section 4.5.

Substances are assessed in two phases: screening and modelling. In each phase, substances are assessed to determine if they are "*liable to cause pollution*". Those which are liable to cause pollution will need to be controlled on the permit.

The screening phase of the assessment has a number of 'tests' which increase progressively in complexity. If a substance fails these tests, it passes through to the modelling assessment. If the screening tests are passed, the substance is classed as insignificant and is screened out. The screening phase uses raw data, where available, as these represent a worst case scenario and minimise the time spent assessing substances which are not liable to cause pollution.

The H1 methodology is designed to assess effects following any reduction in concentrations in any treatment works, and allows for dilution of substances in the receiving water. In the screening phase of the H1 methodology a series of "tests" is undertaken whereby concentrations of substances in the discharge, allowing for dilution in the receiving water, are compared to EQSs.

For freshwater bodies these tests are as follows:

- Test 1 - Does the concentration of the substance in the discharge exceed 10% of the EQS?
- Test 2 - Does the Process Contribution (PC) exceed 4%of the EQS?
- Test 3 - Does the difference between upstream quality and the Predicted Environmental Concentration (PEC) exceed 10% of the EQS?
- Test 4 - Does the PEC exceed the EQS in the receiving water downstream of the discharge?

If the calculated concentration 'fails' the first test then the second test needs to be considered; if the substance also fails this test and either Test 3 or 4 (or both) then further assessment needs to be undertaken to clean-up the data used in the assessment and potentially, modelling of the discharge is likely to be required.

A similar approach is adopted for discharges to the marine environment (within the H1 guidance marine waters are referred to as estuaries and coastal waters). For marine discharges the tests are as follows:

- Test 1 - Does the concentration of the substance in the discharge exceed 100% of the EQS?
- Test 2 – Is the discharge to the low water channel or upper parts of an estuary where the water is mainly fresh?
- Test 3 – Is the discharge to an area with restricted dilution or dispersion?
- Test 4 – Is the discharge location less than 50m offshore from or less than 1m below chart datum?
- Test 5 – If the discharge is buoyant, does the effective volume flux exceed allowable limits?

If the calculated concentration 'fails' the first test then the second test needs to be considered; if this test is true the calculations for freshwater tests 2 to 4 are carried out; if not, if either Test 3 or 4 are true modelling of the discharge is required, or otherwise Test 5 needs to be considered. If the substance also fails this test, modelling of the discharge is required.

The assessments are undertaken to assess the effects from both long-term discharges (based on the annual average (AA) EQS) and short-term effects by comparing the peak discharge concentration to the Maximum Acceptable Concentration (MAC) or 95th percentile concentration (for ease of reporting, in this report, the short-term assessment EQSs are referred to as a 'MAC').

Within the screening methodology, there is also an independent test where for a small number of substances (those substances considered as Priority Hazardous Substances) the substance ‘load’ is calculated for each individual discharge (i.e. the mass discharged over a year). If the load exceeds the ‘significant load’ (a value determined by the Environment Agency/NRW) then the substance will need to be controlled in the permit by a numeric emission limit.

4. Data Sources

4.1 Discharges considered

The following potential construction phase discharges require consideration:

- surface water drainage system discharges dealing with rainfall runoff;
- on-land dewatering discharges from excavations;
- offshore dewatering discharges from behind coffer dams;
- concrete batching plant discharges of process water (this would be disposed of off-site and is not considered as a site discharge in this H1 assessment);
- construction site sewage discharge; and
- Site Campus sewage discharge (this would be discharged via Dŵr Cymru Welsh Water's existing Cemaes Waste Water Treatment Works and is not considered in this H1 assessment).

4.1.1 Surface water drainage

The initial stage of construction work, involves stripping of topsoil from areas of the Wylfa Newydd Development Area to a typical depth of 0.3m and stockpiling the soil in mounds at various locations around the site. Rainwater falling onto the soil mounds and the areas where vegetation and soil have been stripped has the potential to pick up polluting substances as it passes over the surface of the soil-strip areas and mounds and also where it passes through the soils. This stripped soil would eventually be used to cover the landscape mounds that would be constructed around the Wylfa Newydd Development Area. To control runoff from these mounds, which may contain elevated sediment and leached contaminant concentrations, a drainage system would be installed with the rainfall runoff being directed into settlement ponds. Water in these settlement ponds would then be discharged to local watercourses or directly to the sea, although there would be additional treatment as required such as lamella settlement, flocculant and /or coagulant dosing and pH adjustment. The location of the landscape mound areas and the discharge points are shown in Figure 4.1.

It is anticipated that surface water drainage resulting from the construction works would include that from:

- soil strip areas;
- landscape mounds;
- construction areas; and
- contractor's compounds.

As part of localised ground remediation works, some dewatering may be required in an area where trichloroethene contamination has been identified on the northern boundary of the construction area. However, it is proposed that remediation of this area would be undertaken either before construction works commence or at the start of the site clearance works and the water would be treated prior to discharge to remove trichloroethene (see appendix D7-2 (land contamination risk assessment and remediation strategy) (Application Reference Number: 6.4.25) and is therefore excluded from this assessment.

Furthermore, some areas have been identified which may contain elevated concentrations of hydrocarbons (as detailed in appendix D7-2 (Application Reference Number: 6.4.25)) in soils, and potentially in leachate from these soils. These would be subject to separate remediation and contaminated soils from these areas would be removed before any drainage reaches the surface water drainage system.

Substances running off the mounds or open construction areas may enter the drainage water either due to leaching from the soil and migrating in the dissolved phase or the substances may remain in the solid phase within suspended particles picked up by the flowing water. The latter is more likely to occur during high rainfall events when surface water flows are moving quickly. Substances in the solid phase would be removed by a treatment train including silt traps, swales, settlement ponds and associated treatment systems, including lamella clarifiers and dosing to encourage settlement of sediment, prior to discharging at the permitted outfall point.

Surface water runoff from the Site Campus would be treated separately to the rest of the Wylfa Newydd Development Area surface water drainage system. The Site Campus is expected to undergo topsoil stripping, although it is smaller than the other areas subject to topsoil removal and, as the development of this area progresses, an increasing proportion of the runoff would be from hard surfaces. Consequently, the potential to pick up polluting substances would be less than for the rest of the drainage system. Nevertheless, in the absence of a site specific assessment of the potential pollutant loading and to reflect the construction phase of the site when pollutant loading would be highest, the discharge from the Site Campus has been assessed in the same way as other discharges, assuming the same potential pollutant loading.

Where necessary, in order to aid settlement of suspended solids and to reduce concentrations at the outfalls chemicals would be added to act as a flocculent or coagulant. Following discussion with NRW, review of desk based information and laboratory tests on several chemicals an anionic or non-ionic polyelectrolyte has been determined to be the most appropriate coagulant to use.

4.1.2 On-land dewatering from excavations

Dewatering would be required to enable excavation of an area of the site to below the groundwater table during construction work. Discharge from this dewatering would be via settlement ponds (and treatment if required) and then direct to sea at a surface water (marine) drainage outfall point, but the discharge would not be processed through the surface water drainage system.

Water pumped for the initial dewatering would predominantly comprise groundwater from the higher permeability fractured zone at the top of the bedrock. Ongoing dewatering to maintain a dry working area would then consist of continued groundwater ingress plus rainfall. The ongoing discharge would be dominated by rainfall, with an estimated average direct rainfall input of 550m^3/day compared to an estimated groundwater input of around 130m^3/day. Maximum groundwater discharges are estimated at around 200m^3/day with a total maximum discharge being estimated at around 5,700m^3/day as detailed in appendix D8-7 (surface water and groundwater modelling results) (Application Reference Number: 6.4.32).

Although the effect of rainfall input during the ongoing dewatering phase would be to dilute any contaminants in groundwater, the H1 assessment has been based on the groundwater discharge component only in order to account for the initial groundwater dominated phase or during times when there is little or no rainfall. Discharge quality is based upon groundwater monitoring data from pumping tests undertaken within the dewatering area (as detailed in [RD4] and [RD5]). Discharge and rainfall input volumes have been obtained from the modelling detailed in appendix D8-7 (Application Reference Number: 6.4.32).

Groundwater dewatering is also expected to be required during construction of the outfall tunnel. This discharge is considered further in section 4.3.2.

4.1.3 Offshore dewatering from behind coffer dams

Offshore dewatering would take place for the cooling water intake and outfall structures from behind impounding coffer dams which would effectively create a seawater lagoon. The initial phase of dewatering of the coffer-dammed areas would be direct to sea, with the discharge transferred directly across the coffer dams after sediments have settled out in an area behind the dams. As an essentially unaltered discharge back to the same water body, the current H1 guidance [RD2] indicates that this discharge would not require permitting. Consequently, it is not included in the assessment presented in this report.

Subsequently, ongoing dewatering would be required to maintain a dry working area behind the coffer dam. This would consist of rainfall plus seawater and groundwater seepages and would be discharged via the on-land dewatering system (i.e. at a surface water drainage outfall point, but not processed through the surface water drainage system). The larger intake coffer-dam discharge would be dominated by seawater seepage and rainfall and likely volumes to be discharged have been estimated in appendix D8-7 (Application Reference Number: 6.4.32). It is estimated that a combined average input for rainwater and seawater seepage would be 194m^3/day compared to an estimated groundwater ingress of approximately 45m^3/day predicted by modelling (Application Reference Number: 6.4.32). Thus, the groundwater component is only up to around 20% of the total discharge. Furthermore, there would be a natural groundwater discharge into the nearshore area under present conditions. Consequently, the significance of the groundwater component would be small and it has not been considered in the assessment presented in this report

4.1.4 Concrete batching plant

All process water used in the concrete batching plant would be either recycled within the system or, where there is excess, it would be tankered off-site for disposal. There would be no on-site discharge of process water. While there would be no discharge at the site, it is acknowledged that the exported effluent would need to be managed within the permitting regime, e.g. the disposal site would need an appropriate permit, depending on the ultimate location and method of disposal.

Surface water runoff from the concrete batching plant would be discharged via the construction phase drainage system. This runoff would be from hard surfaces and would not be in contact with exposed soils. While there may be specific substances associated with this discharge the pollutant loading would be lower than that in the majority of the surface water runoff derived from the landscape mounds and construction areas due to its relatively small size. The surface water runoff from the batching plant would represent only a small percentage of the total annual surface water discharge and the discharge would be diluted within the surface water drainage system. Consequently, as the significance of this would be small, it has not been specifically considered in the assessment presented in this report.

4.1.5 Construction site sewage discharge

Construction site sewage would be treated by an on-site packaged sewage treatment system. The discharge from this would be direct to sea at the north end of the western breakwater at discharge point CSD. This discharge is considered further in section 5 of this report.

4.1.6 Site Campus sewage discharge

Sewage discharge requirements for the Site Campus would be dealt with by Dŵr Cymru Welsh Water with discharges from the existing Cemaes Waste Water Treatment Works, supplemented by package treatment plant as required, and consequently are not included in the assessment presented in this report.

4.2 Discharge assessment points

There would be eleven discharge points for water discharges associated with construction works that require consideration in this assessment, as detailed in table 4.1 and shown in Figure 4.1 (it should be noted that the grid references are approximate and may vary slightly due to actual site conditions, operation requirements etc). Seven of these discharge points (A1, A3, B1, C1, D1, D2, and E2) are initially to freshwater watercourses, including B1 which discharges to a stream that flows into the Tre'r Gof Site of Special Scientific Interest (SSSI). Discharge point A2 is located on land but is not associated with a surface watercourse. Discharges at this point would enter the sea immediately down gradient from it and, consequently, it is treated as a direct to sea discharge in this assessment. The remaining three discharge points (PA, PB, and PC) are direct to sea. Discharge points PA, PB and PC are located to the north west of the construction area and their use would vary dependent on the sequence of construction although it is likely that PA would only be used for a short time at the start of the construction works. Further details of the drainage scheme are provided in appendix D8-8 (summary of the preliminary design for construction surface water drainage) (Application Reference Number: 6.4.33).

Discharge point E1 is located on the Nant Cemlyn (figure 4.1), but during construction there would be no discharge of treated water to the Nant Cemlyn at this location and no Environmental Permit is required for this location. Instead the water would be treated and pumped to the Afon Cafnan, most likely at discharge point E2. Throughout this document, discharge E1 therefore refers to that water which is collected from the western side of Mound E and which is treated and discharged to the Afon Cafnan at point E2 on the eastern side of Mound E.

Discharge points C1, D1, E2 (including E1) and D2 are consecutive discharges to the same watercourse, the Afon Cafnan (C1 discharges to the Nant Caerdegog Isaf which is a tributary of the Afon Cafnan). Similarly, discharge points B1 and A1 are consecutive discharges to the outflow from the Tre'r Gof SSSI, with B1 entering upstream of the SSSI and A1 entering the watercourse downstream of the Tre'r Gof SSSI at the point where it discharges from the SSSI to the sea. As upstream discharges would potentially increase the upstream concentration for subsequent discharges this has been taken into account in the assessment by using the predicted environmental concentration from an upstream discharge to determine the upstream concentration for the subsequent downstream discharge.

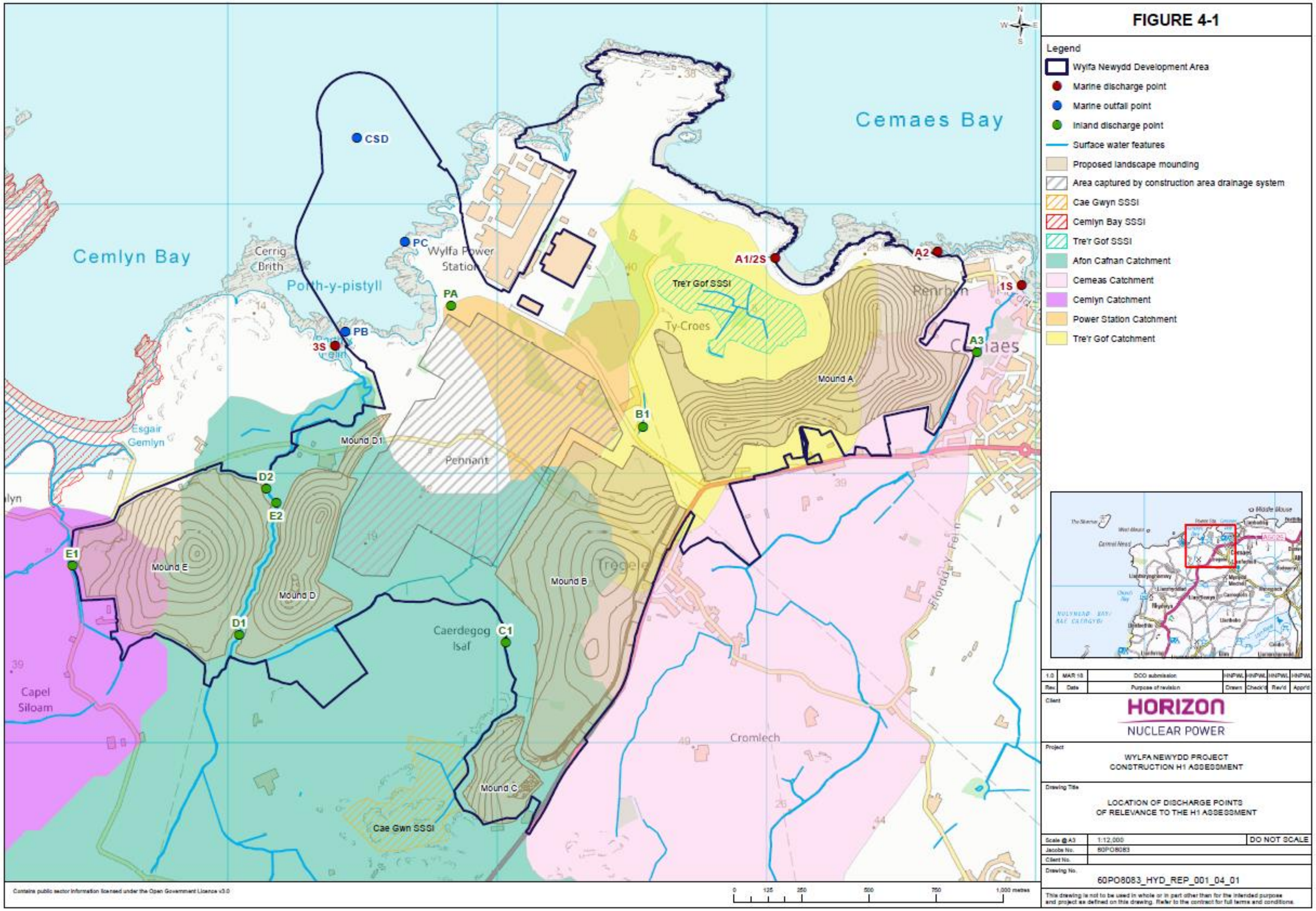
The discharge from on-land dewatering and surface water runoff from the construction platform area would be discharged at PA, PB and PC. The discharges from PB and PC have been modelled separately as the phasing is unknown at this stage. Discharges from PA have not been assessed as PA would only operate for approximately one year and discharge volumes are lower than from PB and PC. All surface water discharge points to the sea are less than 50m offshore from chart datum and the discharge areas are assumed not to have restricted dilution/dispersion characteristics.

Table 4.1 Surface water discharge points of relevance to the H1 assessment.

Runoff area	Outfall reference	Approximate Grid Reference		Receiving water
		Easting	Northing	
Mound A – West and Site Campus	A1	235983	393781	Watercourse which forms the discharge from the Tre'r Gof SSSI
Mound A – Northeast	A2	236633	393779	Cemaes Bay
Mound A - East	A3	236772	393447	Nant Cemaes
Mound B	B1	235539	393117	Small watercourse into north west of the Tre'r Gof SSSI
Mound C	C1	235027	392379	Nant Caerdegog Isaf (tributary to Afon Cafnan)
Mound D - South	D1	234042	392407	Afon Cafnan
Mound D - North	D2	234145	392938	Afon Cafnan
Mound E - West	E1: Mound runoff water captured close to point E1 but discharged at point E2 on the Afon Cafnan			Afon Cafnan
Mound E – East	E2	234174	392897	Afon Cafnan
Power Station site	PA	234825	393626	Porth-y-pistyll
	PB	234435	393528	
	PC	234653	393861	

* Grid reference is approximate pending finalisation of outfall position.

Figure 4.1 Location of discharge points of relevance to the H1 as



4.3 Sources of discharge data

For the assessment of effects, required data relate to the quantity and quality of the discharge water. As these are discharge points which are yet to be constructed, there are no existing monitoring data for the discharges. Discharge data have therefore been estimated from a number of sources as follows.

4.3.1 Discharge flow rates

Discharge flow rates for surface water drainage have been estimated using the 4Rs Model (4R) for shallow groundwater and surface water flows as detailed in appendix D8-7 (Application Reference Number: 6.4.32). The 4R model results provide an estimate of daily flows for each surface water discharge based on simulations using rainfall (and other historical meteorological) data for a 56-year period from 1960 to 2016. The modelling considered three scenarios, a Central baseline and two variants (High and Low) designed to investigate uncertainty in parameter values. The modelling work concluded that the Central baseline model provided the most credible overall results. The average daily discharge rate calculated in the Central baseline model is therefore used for assessing the effects of the long-term discharges in the H1 assessment.

For the peak discharges used to assess the short-term effects, the maximum flow rate is based on the 30-year (plus climate change) rainfall return period for which the settlement ponds and associated water treatment plant is being designed (as detailed in appendix D8-8 (Application Reference Number: 6.4.33)). The maximum discharge rate from the ponds/water treatment plant would be controlled to that which would occur under greenfield conditions. The design basis for the settlement ponds is that the ponds would be able to retain and treat the 1 in 30-year storm flows. The H1 assessment does not cover the effects of a greater than 1 in 30-year rainfall event.

For Tre’r Gof, an assessment of the SSSI has been undertaken which has included the monitoring of groundwater and surface water levels, flows and quality as shown in appendix D8-5 (Tre’r Gof hydroecological assessment) (Application Reference Number: 6.4.30). This assessment noted that based on monitoring in 2015 and 2016, direct rainfall, and not inflows from watercourses, was largely responsible for recharging the basin in which the fen is located. On this basis it was considered that the surface water inflows are not critical to recharge the fen and that direct incident rainfall is more important. As such, the surface water drainage discharges (from outfall B1) are assumed to largely remain confined to the defined drainage channel through the SSSI and discharge at the outfall from the Tre’r Gof SSSI with limited interaction with the bulk of the fen. Furthermore, the drainage system has been designed so that there would be no direct discharges to the eastern compartment of the SSSI which has been identified as the most sensitive zone of the SSSI (appendix D8-5 (Application Reference Number: 6.4.30)) (see figure 4-1 for the extent of the Tre-r Gof SSSI).

On the basis of the above, the drainage channels upstream of and within the Tre’r Gof SSSI are treated as a contiguous surface water drainage system which has limited interaction with the fen. The discharge upstream of the Tre’r Gof SSSI (B1) and the discharges at the Tre’r Gof SSSI outfall (A1) are treated as consecutive discharges to the same watercourse, with the flows provided by the 4R modelling.

The 4R modelling, which is detailed in appendix D8-7 (Application Reference Number: 6.4.32), directed the runoff from the west side of Mound A to discharge points on the south west (upstream) side of the Tre’r Gof SSSI (labelled TG3 and TG4 in the 4R modelling). This is not in accordance with the current drainage design in appendix D8-8 (Application Reference Number: 6.4.33), which routes this runoff to discharge point A1, downstream of the Tre’r Gof SSSI. To account for this difference in the drainage design, these two discharges have been applied to discharge point A1 in the H1 assessment. These two discharges have then been subtracted from the 4R outflow from the Tre’r Gof SSSI (labelled TG5 in the 4R modelling) to give an estimated outflow from the Tre’r Gof SSSI and used in the H1 assessment as the upstream surface water flow for discharge point A1. This methodology may overestimate the discharge at A1 and underestimate the outflow at TG5 from the Tre’r Gof SSSI, as in reality part of the flows at TG3 and TG4 would be natural surface water inflows to the Tre’r Gof SSSI. However, an assessment of the baseline data in the 4R model does show that for the low flow condition (the Q_{95}) the predicted flows are very low at these two points (26m^3/d and 22m^3/d for TG3 and TG4 respectively) and in the context of the H1 assessment this is a conservative approach.

The 4R modelling has not included assessment of the Site Campus area drainage flows. In order to facilitate the H1 assessment it was necessary to estimate potential drainage discharge flows from the Site Campus area. Discharge flows for this area were estimated based on comparison with the modelled flows for the landscape mound catchments as detailed in appendix D8-7 (Application Reference Number: 6.4.32), their 1:30 year runoff rates and their area (appendix D8-8 (Application Reference Number: 6.4.33)), on the assumption that runoff rates from the Site Campus would be similar during its construction. This assessment assumes that all runoff from the Site Campus area would be captured by the drainage system and conveyed to discharge point A1. It is recognised that this is likely to be an over estimate, as in practice only a proportion of the Site Campus area would be developed and this would occur in stages. However, this is a conservative assumption in the context of the H1 assessment.

The average and maximum flows per unit area across the landscape mound catchments were calculated and used to estimate the flows for the Site Campus catchment, based on the estimated catchment area (obtained from project mapping tools). Drainage from the catchment for discharge point A1 was excluded from calculation of this estimate as it includes discharge from the Tre'r Gof Catchment and is unlikely to be representative of drainage primarily from the landscape mounds. The calculations are shown in table 4.2.

The outfall discharge volumes used in the H1 assessment are shown in Table 4.3.

Groundwater discharge flow rates from the on-land dewatering of the excavation have been estimated from modelling results in appendix D8-7 (Application Reference Number: 6.4.32). An average discharge rate of $130m^3/d$ and maximum discharge rate of $192m^3/d$ have been used in the H1 assessment.

Table 4.2 Discharge calculations

Catchment	Drainage discharge point	Catchment area (ha)	Average discharge (m^3/d)	Maximum discharge* (m^3/d)	Average discharge volume (m^3/d/ha)	Maximum discharge volume* (m^3/d/ha)
Landscape mound modelled discharge point catchments						
Mound A - Northeast	A2	4.05	76	12,614	18.76	3,114
Mound A - East	A3	6.22	102	23,674	16.4	3,806
Mound B	B1	39.94	358	45,533	8.96	1,139
Mound C	C1	12.55	213	79,834	16.97	6,361
Mound D – South	D1	4.39	42	15,379	9.57	3,503
Mound D – North	D2	8.77	93	36,202	10.60	4,127
Mound E – West	E2 (water from E1)	14.58	194	83,635	13.31	5,736
Mound E - East	E2	14.68	149	66,528	10.15	4,533
Average					13.09	4,040
Estimated Site Campus catchment						
Site Campus	A1	14.22	**186**	**57,455**	Note: discharge values are indicative	

* Maximum discharge based on 1:30 year (plus climate change) figures. The maximum figures are short term maxima based on an individual storm and are unlikely to be sustained for a full day.

Table 4.3 Discharge volumes for surface water drainage used in the assessment and source of data

Drainage discharge point	Average discharge volume (m^3/s)	Maximum discharge volume (m^3/s)	Comment
A1	0.006	0.787	Includes Mound A west and Site Campus runoff. Source: 4R model output / Surface water drainage design / estimate for Site Campus.
A2	0.0009	0.146	Source: 4R model output / Surface water drainage design.
A3	0.0012	0.274	Source: 4R model output / Surface water drainage design.
B1	0.0041	0.527	Source: 4R model output / Surface water drainage design.
C1	0.0025	0.924	Source: 4R model output / Surface water drainage design.
D1	0.0005	0.178	Source: 4R model output / Surface water drainage design.
D2	0.0011	0.419	Source: 4R model output / Surface water drainage design.
E2 (water from E1)	0.0022	0.968	Source: 4R model output / Surface water drainage design.
E2	0.0017	0.770	Source: 4R model output / Surface water drainage design.
PA/PB/PC	0.005	0.064	Construction area surface water runoff. Source: 4R model output.

4.3.2 Discharge quality

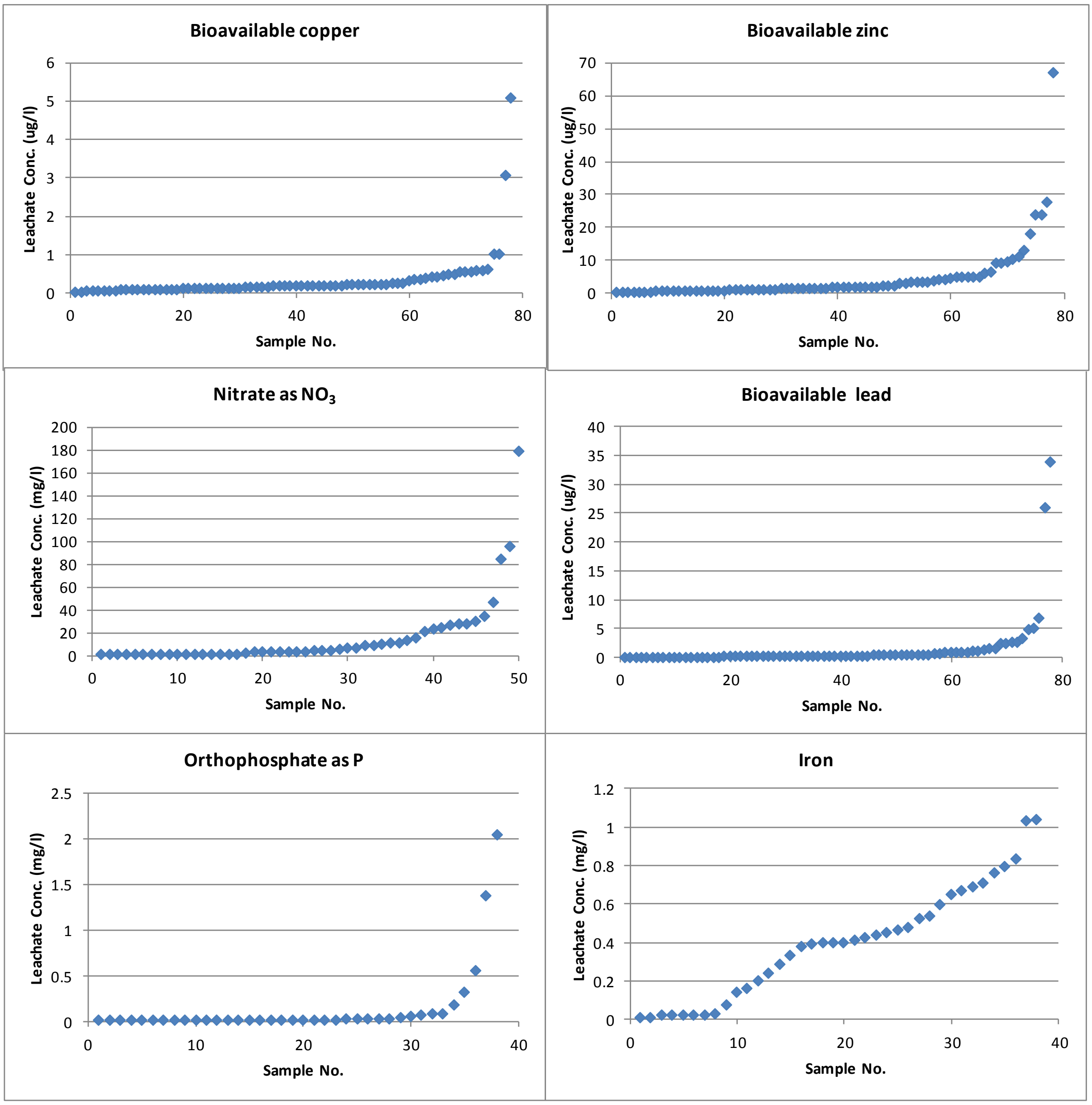
Surface water runoff discharge quality has been estimated from soil leaching tests undertaken as part of ground investigations. The construction works would involve stripping and temporary storage of near-surface soils (nominally defined as the top 0.3m although locally they may go deeper than this dependent on the soil quality) which would then be used to cover the landscape mounds and they would be vegetated. The rock forming the mounds is likely to be relatively inert in terms of leaching potential and, therefore, leaching data from soil samples taken near the surface have been used in the assessment. To ensure a sufficiently large data set and to consider the soils which would be near to the surface following the stripping of soils, data from samples taken from the top 0.5m of soils have been used. It should be noted that no attempt has been made to assign individual samples to each soil strip or landscape mound area and for the assessment it is assumed that the quality of each discharge would be the same.

Leachate testing has been undertaken in several phases of investigation at the site with the analytical schedule varying from investigation to investigation. This has resulted in different numbers of results for each substance. The testing has concentrated on the substances that are most likely to be present in soils so, for example, there are more tests for the principal toxic metals than there are for metals that are less likely to be present.

This methodology will produce a conservative assessment as the leaching tests, carried out under laboratory conditions, were only completed on topsoil, and this constitutes only a small part of the mounds, but is likely to be the most active in terms of leachability. The estimates are considered likely to overestimate the concentrations of substances that would leach from the in-situ mounds, particularly that portion resulting from contact with the more inert rock component. Additionally, it is likely that over time the concentrations of substances in the drainage water would reduce as soils become more compact and vegetation establishes itself on the bare soils such that percolation through the landscape mounds follows established flowpaths and there is less loose soil material on the surface to enter the suspended solids phase. Furthermore, as there is a finite amount of each substance in the soil within the mounds, the concentrations of substances in the dissolved phase are likely to reduce over time as the more easily leached material is removed.

Figure 4.2 shows the distribution of results for the topsoil leaching tests for selected metals and orthophosphate which have been identified later in this report as being of most concern (results are ordered in increasing concentration). It can be seen that some of these data sets have outliers. However, in line with the H1 assessment methodology the arithmetic mean value for all leachate concentrations has been used even though in some cases extreme values are creating bias in the mean (arithmetic mean values are heavily influenced by extreme values). Furthermore, and in line with the H1 methodology, where a value is detected below the limit of detection (LoD), the data used to calculate the mean uses the detection limit value in the calculation (for example, if a leachate concentration is reported as <1μg/l, then a value of 1μg/l has been used in calculating the mean). This can result in an overly conservative assessment and is considered further in the “clean-up” of data following presentation of the screening assessment.

Figure 4.2 Distribution of leachate results for selected dissolved metals, nitrate and orthophosphate



A summary of the potential discharge quality data used in the H1 assessment is provided in appendix A. The assessment has been undertaken for substances including metals (including bioavailable metals where relevant), inorganic ionic substances, and organic compounds associated with fuels (polycyclic aromatic hydrocarbons (PAHs) and total petroleum hydrocarbons (TPHs)). Only those substances where concentrations above the LoD have been detected in one or more leachate sample are considered. Figure A1 (in Appendix A) shows the location of soil sampling points which have been used to determine the discharge concentration, although it should be noted that not all samples were tested for all determinands. The sample set includes samples which have been taken from areas which have been identified as "Areas of Potential Concern" (APCs) where concentrations of certain substances may be higher (for details of the APCs see Application Main Site D7 – Soils and Geology (Application Reference Number: 6.4.7)).

For certain metals, the EQS is set as a "bioavailable" metal which cannot be directly analysed. For estimating the concentration of bioavailable metals in the discharge, the concentration has been calculated using the WFD UK Technical Advisory Group (UKTAG) m-bat spreadsheets [RD6]. Where leaching tests measured the pH, dissolved organic carbon (DOC) and calcium concentrations (which are the parameters required to calculate the bioavailable metals along with the dissolved metal concentration) these have been used to calculate the bioavailable metal in the leachate. However, not all of the leaching tests measured all of these parameters and in this case the average values recorded in surface waters has been used to calculate the bioavailable metals that may be present in the discharge.

As noted earlier, the use of a coagulant to aid the settlement of suspended solids within the drainage discharge has been considered. "Jar tests" have been undertaken to determine the likely settlement rate for solids and what the final suspended solids concentration in the discharge from each settlement pond could be. These tests have involved the use of alternative coagulants to aid settlement and assess if such treatment is required to ensure the required suspended solids concentrations are met in the discharges. The assessment of the jar tests does indicate that treatment would be required in order to achieve the suspended solids concentration specified in the project design.

An anionic or non-ionic polyelectrolyte would be used in the treatment system and the jar tests have been used to estimate the concentration of dissolved substances this may generate in the discharge, i.e. derived from the polyelectrolyte itself (referred to as "carry over"). These tests are reported in [RD7] and the results summarised in table 4.4. The results show that the carry-over of dissolved major ions associated with the use of these polyelectrolyte coagulants is relatively low and typically plus or minus a few mg/l. The polyelectrolyte dosage used in these tests ranged from 2 to 12 mg/l, considerably more than the 0.5 to 1 mg/l dosage that is proposed to be used in the drainage system (appendix D8-8) (Application Reference Number: 6.4.33). Each discharge point would have its own dosing infrastructure. The proposed polyelectrolyte dosing would also be intermittent, applied only when required. Consequently, as these are not substances of particular concern in the drainage discharges and as the potential carry over is very small, they do not affect the H1 assessment. However, the polyelectrolyte itself has been included in the H1 assessment. In the absence of a specific evaluation of potential dosage rates and durations, the maximum proposed dosage rate of 1 mg/l as a continuous discharge has been assumed.

Table 4.4 Dissolved carry over concentrations from polyelectrolyte jar tests

Substance	Potential change in discharge (mg/l)
Alkalinity (as CaCO3)	0 to -10
Calcium	1 to 2
Magnesium	0.5 to 1
Sodium	2 to 5
Potassium	0 to -0.2
Chloride	0 to -2
Nitrate	2.2 to -2.4
Sulphate	3 to -4.8

To assess potential TPH levels, the analysis carried out on leachate samples involved speciation of the TPH to identify carbon chain length and split of aromatic and aliphatic compounds. TPH compounds were detected in four leachate samples and in this assessment the total aromatic and aliphatic concentration is used rather than assessing each individual class.

Whilst it is normal that for assessing short term impacts in the H1 methodology for comparison to MACs the maximum discharge concentration would be used, this really only applies where there is time series rather than spatial data. The data used for this assessment are spatially distributed so the maximum concentration for each substance derived from the leaching tests only relates to soils from that specific location and does not suggest that this value could occur at all other locations. The soils that will be placed in any particular area will be a mixture, potentially from across the Wylfa Newydd Development Area, and it is highly unlikely that soils which produced the maximum leachate concentration would be placed in isolation and so result in the maximum leachate concentration in the discharge. Furthermore, for short-term effects it is unlikely that the dissolved phase concentration would increase with a higher discharge rate (the maximum discharge rate is used for assessing short term effects). Indeed, it is more likely that at times of higher flow the concentration would decrease as there would be a higher proportion of surface runoff which has not percolated through the landscape mounds and a shorter contact time between the soil and percolating water. Therefore, in assessing the short-term effects for comparison to the MACs, the mean leachate concentration has been used which is considered to be the maximum conceivable concentration at times of high flow.

Groundwater dewatering discharge quality for the construction site excavations has been based on groundwater quality sampling carried out during on-site pumping tests as detailed in [RD4] and [RD5]. These tests were carried out in the area in which dewatering would take place and so are considered likely to reflect the water quality of the dewatering discharge. A summary of the potential dewatering discharge quality data is provided in appendix A.

Groundwater dewatering associated with construction of the outfall tunnel would take place in an area expected to reflect normal background groundwater quality. TPH contamination has been reported in this area historically, however recent groundwater sampling has not identified any significant concentrations of hydrocarbons in the area of the proposed outfall tunnel (all results from this area were below the level of detection in the August 2017 sampling round as detailed in appendix D8-3 (groundwater baseline report) (Application Reference Number: 6.4.28)). Any free-phase hydrocarbon contamination identified would be removed prior to discharge to the marine environment. Consequently, the dewatering of the tunnel would not result in any marine EQS breach

The expected discharge quality for the output from the construction site sewage plant is reported in [RD8]. This discharge is considered further in section 5.4 of this report.

4.4 Sources of data for the receiving watercourses

In relation to the watercourses which the discharges enter, required data relate to quantity and quality of the surface water in the Nant Cemaes, the Afon Cafnan and tributary and flows into and out of the Tre'r Gof SSSI. Data sources for these are outlined below.

4.4.1 Surface water flow rates

For Tests 2 to 4 of the H1 screening assessment, dilution in the receiving water is taken into account. To measure surface water flow rates, flumes have been installed on the inflows and the outflow of the Tre'r Gof SSSI and on Nant Caerdegog Isaf, the Afon Cafnan tributary. Spot gauging of flows on other watercourses has also been undertaken, although data are limited for many locations. Details are provided in appendix D8-1 (surface water baseline report) (Application Reference Number: 6.4.26) To supplement the measured surface water flows, the catchments have been modelled using the 4R model as detailed in appendix D8-7 (Application Reference Number: 6.4.32) in order to estimate flows during the construction phase. The model predicts the daily average flow at a point upstream of each discharge point based on a simulation using rainfall and associated meteorological data for the period 1960 to 2016.

In line with the H1 guidance, the dilution needs to be considered in the low flow (Q_{95}) conditions. The 4R model output, which is based on a 56 year time period, has therefore been used to provide an estimate of the Q_{95} flow at a point immediately upstream of the discharge point (where these are to a watercourse) or to assess the total flows into the Tre'r Gof SSSI. Flow rates used for the watercourse flows at each discharge point are shown in table 4.6.

Table 4.6 Receiving water flow rates (Q_{95}) used in the H1 assessment

Drainage discharge point (outfall)	Surface water flow rate upstream of discharge point (m^3/s)
A1	0.0005
A3	0.0027
B1	0.00003
C1	0.00042
D1	0.0174
D2	0.0176
E2 (from E1)	0.0180
E2	0.0177

4.4.2 Surface water quality

Surface waters have been and are continuing to be monitored for quality (although not for all determinands are used in the H1 assessment) with samples having been collected from watercourses around the Wylfa Newydd Development Area on a quarterly basis in 2013 and 2014 and more recently on a monthly basis. In addition, continuous recording of turbidity, pH, dissolved oxygen, temperature and electrical conductivity is undertaken on the Nant Caerdegog Isaf. This monitoring is reported in appendix D8-1 (Application Reference Number: 6.4.26).

Surface water quality data have been collected from spot measurements on the watercourses at or close to the various discharge points. As these are to be new discharges, results from samples collected from downstream of the proposed discharge points are also valid for establishing the existing baseline. Existing surface water quality data are shown in appendix B for the relevant discharge points.

For those metals for which the EQS is set as a bioavailable metal, the WFD UKTAG m-bat spreadsheets [RD6] have been used to estimate the concentration of the bioavailable metal. Where the dissolved organic carbon (DOC) measurement has been made, the actual recorded DOC for that sample location has been used to calculate the bioavailable concentration. If the DOC was not recorded with the sample, then the average recorded DOC concentration for all surface waters of 8.6mg/l was used. A similar approach was adopted for the other determinands required to estimate the bioavailable metal (calcium and pH) with an average value for calcium being 45 mg/l and an average pH of 7.3.

In line with the H1 guidance, where a substance has not been tested in the surface water, a value of 10% of the EQS is assumed as the upstream water quality. This assumes that as the discharges are to watercourses within a rural area, there are no other polluting discharges to the watercourse upstream of the discharge point (for those parameters which are tested, the analysis would indicate an un-contaminated stream).

4.5 Water quality standards

The water quality standards used for the assessment are primarily the EQSs provided in guidance on undertaking surface water impact assessments published by the Environment Agency on the UK Government’s website [RD2]. Values applicable to freshwater and marine waters have been used where they are available.

Where an EQS is not provided in the above document, then values as shown in the Environment Agency’s Chemical Standards Database [RD9] have been used. These are based on other legislative drivers, some of which are now repealed such as the Freshwater Fish Directive (which has been replaced by the requirements of the WFD). If a standard is not available from either of the above sources, then a predicted no effect concentration (PNEC) value has been used as referenced in appendix C.

Where relevant, AA and 95th percentile/MAC values have been used to assess the potential significance of long-term and short-term effects respectively. The water quality standards used for this assessment are shown in appendix C. For polyelectrolytes, the EQS provided in NRW guidance [RD3] has been used.

5. Results of Screening Assessment

5.1 Results of freshwater screening assessment

The results of the screening assessment for freshwaters where there is an EQS or PNEC are presented in appendix D. Tables 5.1 and 5.2 summarise the results (as presented in appendix D) for the four tests for the Part A assessment, for the long-term and short-term assessments respectively. These tables record failures (Y) or passes (N) of the tests summarised across all assessed discharge points. All failures are highlighted yellow.

Table 5.1 Results of surface water runoff tests for long-term freshwater assessment

Substance	Test 1	Test 2*	Test 3*	Test 4*
	Is discharge concentration > 10% of AA EQS?	Test 2 - Is PC > 4% of AA EQS?	Is difference between upstream concentration and PEC >10% of AA EQS?	Is PEC > AA EQS?
Inorganics				
Chloride	N			
Sulphate	N			
Ammoniacal nitrogen	Y	Y	N	N
Phosphate (orthophosphate as P)	Y	Y	Y	Y
Nitrate (as NO_3)	Y	Y	Y	N
Metals				
Antimony	N			
Arsenic	N			
Boron	N			
Cadmium	Y	Y	Y	Y
Cobalt	Y	Y	Y	N
Copper (bioavailable)	Y	Y	Y	N
Chromium (III)	Y	Y	Y	N
Iron	Y	Y	Y	N
Lead (bioavailable)	Y	Y	Y	Y
Manganese (bioavailable)	Y	Y	N	N
Molybdenum	N			
Nickel (bioavailable)	N			
Selenium (dissolved)	Y	Y	Y	N
Vanadium	N			
Zinc (bioavailable)	Y	Y	Y	N
Organics				
Anionic Polyelectrolyte	Y	Y	Y	N
Total petroleum hydrocarbons	N			
Anthracene	Y	Y	Y	N
Benzo(a)pyrene	Y	Y	Y	Y
Fluoranthene	Y	Y	Y	Y
Naphthalene	N			
Phenol	Y	Y	Y	N

*Tests 2, 3 and 4 apply to individual discharges. A "Y" in a yellow shaded box in the above table indicates that a test was exceeded in one or more discharge. Substances in bold show where the substance fails both Test 1 and Test 2 and either Test 3 or Test 4, indicating modelling assessment is required for that substance.

Table 5.2 Results of surface water runoff tests for short-term freshwater assessment

Substance	Test 1	Test 2*	Test 3*	Test 4^
	Is discharge concentration > 10% of MAC EQS?	Test 2 - Is PC > 4% of MAC EQS?	Is difference between u/s conc and PEC >10% of MAC EQS?	Is PEC > MAC EQS?
Metals				
Cadmium	Y	Y	Y	N
Cobalt	N			
Chromium (III)	N			
Lead (dissolved)	Y	Y	Y	N
Mercury	Y	Y	Y	Y
Nickel (dissolved)	N			
Organics				
Anthracene	Y	Y	Y	N
Benzo(a)pyrene	N			
Benzo(b)fluoranthene	Y	Y	Y	Y
Benzo(k)fluoranthene	Y	Y	Y	Y
Benzo(g,h,i)-perylene	Y	Y	Y	Y
Fluoranthene	Y	Y	Y	N
Naphthalene	N			
Phenol	N			

*Tests 2, 3 and 4 apply to individual discharges. A "Y" in a yellow shaded box in the above table indicates that a test was exceeded in one or more discharges. Substances in bold show where the substance fails both Test 1 and Test 2 and either Test 3 or Test 4, indicating modelling assessment may be required for that substance, following clean-up of data.

The results show that for the substances in bold in tables 5.1 and 5.2, the effects to the receiving waters are potentially significant and further assessment of the substances is required. This modelling assessment is provided in section 6.

5.2 Results of marine screening assessment

5.2.1 Test 1

For marine waters, Test 1 compares the discharge concentration to the marine water EQS and if the concentration of the substance in the discharge is less than the EQS then the impact of that substance can be considered as insignificant. The calculations from Test 1 for marine waters are presented in appendix D (Table 1 for surface water runoff and Table 5 for groundwater dewatering discharge) and show that the predicted discharge concentrations are in excess of the EQS for a small number of substances as summarised in table 5.3 for surface water runoff and table 5.4 for groundwater dewatering discharge.

Table 5.3 Results of surface water runoff long-term and short-term Test 1 for marine waters

Substance	Test 1 – Long-term Is discharge concentration > 100% of AA EQS?	Test 1 – Short-term Is discharge concentration > 100% of MAC EQS?
Anionic Polyelectrolyte	N	
Metals		
Antimony	N	
Arsenic	N	
Boron	N	
Cadmium	Y	
Cobalt	N	N
Copper (dissolved)	Y	
Iron	N	
Lead (dissolved)	Y	N
Mercury		Y
Molybdenum	N	
Nickel (dissolved)	N	N
Selenium (dissolved)	N	
Vanadium	N	
Zinc (dissolved)	Y	
Organics		
Total petroleum hydrocarbons	N	
Anthracene	N	N
Benzo(a)pyrene	Y	N
Benzo(b)fluoranthene		Y
Benzo(k)fluoranthene		Y
Benzo(g,h,i)-perylene		Y
Fluoranthene	Y	N
Naphthalene	N	N
Phenol	N	N

A "Y" in a yellow shaded box in the above table indicates that a test was exceeded in one or more discharges. Substances in bold show where the substance fails Test 1 indicating modelling assessment may be required for that substance, following clean-up of data

Table 5.4 Results of groundwater dewatering discharge long-term and short-term Test 1 for marine waters

Substance	Test 1 – Long-term Is discharge concentration > 100% of AA EQS?	Test 1 – Short-term Is discharge concentration > 100% of MAC EQS?
Cyanide^	Y	Y
Metals		
Arsenic	N	
Boron	N	
Cadmium	N	
Copper (dissolved)	N	
Chromium (VI)*	Y	Y
Iron	N	
Lead (dissolved)	N	N
Mercury		N
Nickel (dissolved)	Y	N
Selenium (dissolved)	N	
Vanadium	N	
Zinc (dissolved)	Y	
Organics		
Anionic Polyelectrolyte	N	
Total petroleum hydrocarbons	N	
Anthracene	Y	Y
Benzo(a)pyrene	Y	Y
Benzo(b)fluoranthene		Y
Benzo(k)fluoranthene		Y
Benzo(g,h,i)-perylene		Y
Fluoranthene	Y	Y
Naphthalene	N	N
Phenol	N	N

Substances in bold show where the substance fails Test 1 indicating modelling assessment is required for that substance.

^ For cyanide, all sample results were below the level of detection of 5µg/l or 10µg/l. The marine AA EQS for cyanide is 1µg/l and the MAC is 5µg/l. However, detection limits for cyanide lower than 5µg/l are not available at commercial laboratories. Cyanide has not been identified in ground investigations as a contaminant of concern.

* For chromium (VI), the detection limit exceeds the EQS. However, in groundwater due to the redox conditions, the chromium (III) ion predominates with little or no Chromium (VI). The groundwater analysis shows very low concentrations of dissolved chromium (a maximum of 7µg/l with 23 of the 25 samples having concentrations below the limit of detection of 1µg/l) and as such the chromium (VI) concentration is very likely to be below the marine AA EQS for chromium (VI) of 0.6µg/l and will be below the MAC of 32µg/l.

The results show that for the substances in bold in table 5.3 and table 5.4 the effects to the receiving waters are potentially significant and further assessment of the substances is required in accordance with the further tests in the H1 guidance for marine waters.

For inorganic substances that are likely to be in the groundwater discharge and for which there is no published EQS or PNEC, the concentrations of sulphate and chloride are such that the concentration will be significantly below the natural concentrations in sea water (Table 5.5). For other determinands the concentration in the groundwater is in excess of the concentration that has been typically recorded in the sea water off Wylfa Head, although as noted later in this report there will be rapid mixing of discharges in a relatively small mixing zone.

Table 5.5 Inorganic concentrations in groundwater compared to typical values for sea water (all results as mg/l)

Substance	Concentration in groundwater*	Typical sea water concentration/ values sampled off Wylfa Head	Data source
Chloride	52.44	19,400	http://www.seafriends.org.nz/oceano/seawater.htm
Sulphate	30	2,650	http://www.wcponline.com/2005/01/31/water-desalination-processes-associated-health-environmental-issues/ and from baseline data collected at Wylfa between May 2010 and November 2014
Phosphorous (total dissolved)	0.025	0.02	From baseline data collected at Wylfa between May 2010 and November 2014
Ammoniacal nitrogen (as NH_4)	0.032	0.02 or less	From baseline data collected at Wylfa between May 2010 and October 2013
Nitrate (as NO_3)	3.5	0.44	From baseline data collected at Wylfa between May 2010 and November 2014
Total nitrogen^	0.81	0.1 or less	From baseline data collected at Wylfa between May 2010 and November 2014

* Mean values with the detection limit used to calculate the mean value where required
^ For groundwater TN = sum of ammoniacal nitrogen and nitrate expressed as N. For the marine samples the analysis also included total organic nitrogen.

5.2.2 Further tests for marine discharges

For substances that fail Test 1 for marine waters, a series of further tests are specified (as described in section 3 of this report). The results of these tests are outlined below with further assessment provided in appendix E.

Test 2 – Check whether the discharge is to the low water channel in an estuary:

This does not apply to the assessed discharges.

Test 3 - Check whether the discharge is to a location with restricted dilution or dispersion

This is considered not to apply to the assessed discharges.

Test 4 - Check whether the discharge point is located less than 50m offshore from chart datum, or is located less than 1m below chart datum

This applies to all discharges and consequently all require further assessment of the identified substances by modelling.

Test 5 – Check if the effective volume flux of the discharge is within allowable limits

The further assessment of these substances by modelling is described in section 6.

5.3 Priority hazardous pollutants screening

The priority hazardous pollutants screening test calculates the annual loads discharged from each discharge point for the 13 designated priority hazardous substances shown in appendix F and compares the load to prescribed limits. Calculation of the loads for the discharges is shown in Table 1 of appendix F and shows that for substances which have been tested in leachate and groundwater samples, the substances do not exceed the prescribed limit and that the total discharge loads for the site do not exceed the prescribed limits.

For those substances where the chemical was tested in the DOnGI investigation in soils or leachate but was not detected in any sample, the load for that chemical has not been estimated as the concentrations in the discharge (if present at all) would be very low with subsequent low loads. For those determinands which have not been tested, the hazardous substances are of industrial origin and given the historical land use of the Wylfa Newydd Development Area and absence of other substances of similar origin, they are very unlikely to be present in the soils or subsequent leachate from the soils.

5.4 Construction site sewage discharge

Treated effluent from the on-site package sewage treatment plant would be discharged direct to sea from the tip of the western breakwater (CSD) in the north of Porth-y-pistyll. This discharge is distinct in character from the other surface water and dewatering discharges in that it is not driven by rainfall but by the number of workers on site and so, and in line with the H1 guidance, a separate assessment has been undertaken. The following information has been identified.

The package treatment plant maximum flow would be $990m^3/d$, which includes a 10% headroom allowance. Maximum instantaneous flow would be 11.5l/s. Secondary treatment has been assumed, with a discharge quality standard of 20mg/l:30mg/l:20mg/l (BOD:Suspended Soilds:Ammoniacal Nitrogen), which reflects the effluent discharge standard at the existing Cemaes WwTW.

Only ammonia has been assessed in the sewage effluent. Unionised ammonia concentrations depend on the equilibrium between the ammonium ion (NH4+) and unionised ammonia (NH3). The position of the equilibrium is affected by temperature, pH and salinity. The value for ammoniacal nitrogen would always be greater than the unionised ammonia fraction. The ammoniacal nitrogen concentrations following conventional treatment and after initial dilution would be 0.016mg/l (as N) as an Annual Average (AA) and represent a worst case. This falls below the long-term (mean) EQS for coastal waters of 0.021mg/l. Although the latter is for NH3-N (un-ionised), as the concentration expressed as NH4-N would be greater than when expressed as NH3-N, the concentration after treatment would be below the EQS.

This therefore meets the required standards and would not affect water quality in coastal WFD water bodies. Assuming a worst case temperature (maximum from baseline was 16.7ºC), maximum pH (8.3) and salinity (34) the combined total ammonia concentration (baseline of <0.021mg/l plus the process contribution of 0.016mg/l as a worst case) would result in a non-ionised ammonia concentration after initial dilution of <1.57µg/l which is well inside the EQS for coastal waters (21µg/l).

Dispersion modelling to understand potential effects related to bacteria and suspended solids has been undertaken assuming a worst case flow of 18.5l/s. Details are provided in appendix D13-8 (hydrodynamic modelling) (Application Reference Number: 6.4.90).

6. Clean-up of data and modelling test results

6.1 Introduction

The H1 guidance identifies that following the screening tests, any substances which are identified in screening as being potentially significant need to be assessed (modelled) in more detail using ‘cleaned-up’ data. Following the modelling assessment, the results will show whether the discharges will cause pollution or not. If the modelling tests show that the discharge could cause pollution then the discharge would be controlled in the permit or, if the impact on the environment is unacceptable, a permit for a discharge of that substance may not be issued.

The methodology set out in H1 guidance has been used for the required clean-up of data. Following this methodology, the raw sample data used in the screening assessment need to be further assessed and ‘cleaned up’ by:

- checking whether the discharge is truly liable to contain a substance; and
- checking that the data are truly ‘fit for purpose’.

6.2 Clean-up of data

6.2.1 Discharges ‘liable to contain’ substances

The initial stage of the clean-up of the input data checks whether the discharge is truly liable to contain a substance. A substance may have been carried through to modelling even though it was not really detected in many of the discharge samples because the ‘less than’ values are taken at face value in the precautionary screening stage. The H1 guidance shows the minimum number of samples that are required to exceed the LoD to determine if the discharge is liable to contain a substance (table 6.1). If the required number of samples were reported above the LoD then clean-up of the data and modelling should be undertaken.

Table 6.1 Minimum number of samples required to exceed the limit of detection

Number of samples in assessment period	Minimum number of samples which need to be equal to or above the required LOD
12 to 14	4
15 to 20	5
21 to 27	6
28 to 34	7
35 to 41	8
42 to 48	9
49 to 56	10
57 to 63	11
64 to 71	12

For those determinands shown as being carried over to modelling in tables 5.1, 5.2, and 5.3, tables 6.2 and 6.3 identify the number of samples tested for each substance and how many samples exceeded the LoD and whether the discharge is liable to contain the substance based on the H1 guidance.

The results of the assessment show that for the surface water runoff (table 6.2), the discharges are not liable to contain PAHs and no further assessment has been undertaken for these substances. The assessment also shows that for cadmium, cobalt, mercury and selenium the number of measurements greater than the limit of detection is not significant in comparison to the total number of analyses, and these metals can therefore be excluded from further assessment.

Table 6.2 Assessment of whether the surface water runoff discharges are liable to contain a substance

Substance	Number of leaching test results	Number of results equal to or above the LoD	Is the discharge liable to contain the substance and further modelling needed?	Receiving water substance applies to: F – Freshwater M– Marine water (LT) long-term (ST) short-term
Inorganics				
Orthophosphate (as P)	38	15	Y	F (LT)
Nitrate (as NO_3)	50	42	Y	F (LT)
Metals				
Cadmium	76	5	N	
Cobalt	46	4	N	
Copper (bioavailable)	78	77	Y	F (LT)
Copper (dissolved)	78	77	Y	M (LT)
Chromium (III)	78	47	Y	F (LT)
Iron	38	32	Y	F (LT)
Lead (bioavailable)	48	34	Y	F (LT)
Lead (dissolved)	48	34	Y	F (ST) M (LT)
Mercury	46	2	N	
Selenium	46	0	N	
Zinc (bioavailable)	78	74	Y	F (LT)
Zinc (dissolved)	78	44	Y	M (LT)
Organics				
Anthracene	48	3	N	
Benzo(a)pyrene	48	1	N	
Benzo(b)fluoranthene	48	2	N	
Benzo(k)fluoranthene	48	1	N	
Benzo(g,h,i)perylene	48	2	N	
Fluoranthene	48	2	N	
Phenol*	10	1	N	

* For phenol, only 10 samples were analysed rather than the minimum number of 12 shown in the H1 guidance. However, given that only one sample detected phenol (and this was only marginally above the limit of detection) and phenol has not been identified as a contaminant of concern in the contaminated land assessment or elsewhere, it is considered that the discharge is not liable to contain this substance.
Data taken from table A1 of appendix A.

For the groundwater dewatering (table 6.3), the assessment shows that the discharges are not liable to contain PAHs and no further assessment has been undertaken for these substances. The assessment also shows that for cyanide and chromium VI the number of measurements greater than the limit of detection is not significant in comparison to the total number of analyses, and these substances can therefore be excluded from further assessment.

Table 6.3 Assessment of whether the groundwater dewatering discharge is liable to contain a substance

Substance	Number of sample test results	Number of results equal to or above the LoD	Is the discharge liable to contain the substance and further modelling needed?	Receiving water substance applies to^: F – Freshwater M– Marine water (LT) long-term (ST) short-term
Cyanide*	23	0	N	
Metals				
Chromium (VI)*	23	0	N	
Nickel (dissolved)	25	20	Y	M (LT)
Zinc (dissolved)	25	25	Y	M (LT)
Organics				
Anthracene	25	1	N	
Benzo(a)pyrene	25	1	N	
Benzo(b)fluoranthene	25	1	N	
Benzo(k)fluoranthene	25	1	N	
Benzo(ghi)perylene	25	1	N	
Fluoranthene	25	4	N	

* For Cyanide and Chromium (VI) the LOD is greater than the EQS. However, these substances have not been identified as contaminants of concern in the contaminated land assessment and are considered not to require further assessment.
^ Groundwater is only discharged to marine waters

6.2.2 Assessing if the data are "fit for purpose"

Before using any chemical data in the modelling, the H1 guidance states that the discharge quality data set should be checked to ensure that it is representative of the discharge. In relation to the substances which may potentially be in the discharges from the surface water drainage settlement ponds, the following checks are relevant:

- determine if there are any outliers in the data; and
- adjust "less than" values by replacing results that are reported as "less than" with 50% of the LoD value.

Table 6.4 identifies the outliers and recalculated mean values using the new leaching test data sets for surface water runoff (including results corrected to 50% of the LoD). For orthophosphate, nitrate, copper (dissolved and bioavailable) and iron no outliers are identified and the mean values do not differ significantly from the value used in the screening assessment. For the others, outliers have been identified from a visual assessment of the data presented in figure 4.2 which has resulted in mean concentrations lower than the original mean (table 6.4). For the other determinands, where the change has only been to use half of the detection limit in the calculation of the mean, the means of the original and cleaned up data show very little difference. For polyelectrolyte, the concentration in the cleaned up data has not changed from the initial concentration as this is based on a theoretical value rather than leaching test results.

Table 6.4 Clean-up of surface water runoff data to allow for outliers and correction of LoDs

Substance	Outliers identified (location, depth and concentration)	Mean value used in screening (µg/l)	Mean value of cleaned-up data (µg/l)	Standard deviation of cleaned-up data (µg/l)
Inorganics				
Orthophosphate (as P)	None	138	133	396
Nitrate (as NO_3)	None	15,036	15,006	30,556
Metals				
Copper (bioavailable)	H1S17 (0 to 0.2m) 5.08µg/l XTP068 (0.5m) 3.07µg/l	0.4	0.3	0.2
Copper (dissolved)	None	9.3	9.3	7.0
Chromium (III)	PC7TP11 (0.5m) 25.0µg/l	2.02	1.52	1.35
Iron	None	395	394	294
Lead (bioavailable)	TP700/22 (0.4m) 26.0µg/l TP800/30 (0.5m) 33.8µg/l	1.4	0.7	1.2
Lead (dissolved)	TP700/22 (0.4m) 224µg/l TP800/30 (0.5m) 291µg/l	13.0	6.5	11.0
Zinc (bioavailable)	TP800/28 (0.5m) 66.6µg/l	4.4	3.6	5.4
Zinc (dissolved)	TP800/28 (0.5m) 218µg/l	14.1	11.4	13.3
Polyelectrolyte				
Anionic polyelectrolyte	None	1000	1000	0

Table 6.5 identifies the outliers and recalculated mean values for the groundwater dewatering data set for dewatering discharge (including results corrected to 50% of the LoD). Only one outlier was identified, this being for nickel. Although the range of recorded zinc values is quite large across the two pumping tests from which the data was derived, there are no obvious outliers. As such, the mean values of the cleaned up data do not differ significantly from the values used in the screening assessment.

Table 6.5 Clean-up of groundwater dewatering data to allow for outliers and correction of LoDs

Substance	Outliers identified (location and date)	Mean value used in screening (µg/l)	Mean value of cleaned-up data (µg/l)	Standard deviation of cleaned-up data (µg/l)
Metals				
Nickel (dissolved)	PW2 (23-Oct-15)	16.5	13.8	13.1
Zinc (dissolved)	None	38	38	34

6.3 Modelling of freshwater discharges

Modelling of discharges to freshwater has been carried out using the Monte Carlo RQP (River Quality Planning) software (version 2.5) provided by the Environment Agency [RD10]. The guidance associated with the model indicates that the modelling results should be assessed by the tests outlined below.

- **Test 1 - Risk to EQS**. This test assesses whether the proposed, or permitted, load could cause failure of the receiving water EQS.
- **Test 2 - Significant deterioration of receiving water quality**. This test determines whether the discharge causes downstream deterioration with the watercourse quality deteriorating by more than 10% of the EQS.

For the Afon Cafnan and the Nant Caerdegog Isaf where there would be consecutive discharges to the same watercourse (at points C1, D1, E2 (incl. E1), and D2) and the discharge concentrations are the same, the RQP modelling assessment has been applied at the most upstream discharge point (C1) as this is the point where there would be the greatest change in concentration as further downstream the concentrations in the receiving water would be impacted by the upstream discharge(s). The predicted environmental concentrations for the substances that require modelling assessment are similar at each point and at this point the upstream flow, and consequently dilution potential, is lowest and the greatest increase over natural background concentrations is expected.

The sources of data used in this modelling are shown in table 6.6 and the results of this modelling are presented in appendix G. The model has been used in both its “forward” and “backward” modes, the former to show the predicted surface water concentration at each outfall for the expected watercourse flow rates and concentrations and the latter to determine the concentrations in the discharge which would be needed to breach the EQS in the receiving watercourse. The model has assumed a positive correlation of 0.6 for the discharge flow rate and the upstream river flow rate as it is likely that both flows would be controlled by rainfall rates. Summary of the modelling results is shown in table 6.7 for Test 1 (exceedance of the EQS) and table 6.8 for Test 2 (10% deterioration of water quality downstream of the discharge). Table 6.7 also shows what limits would be required in order to protect the immediately receiving watercourse so that the EQS is not exceeded.

Table 6.6 Data sources used in the RQP modelling

Data	Data source	Reference
Outfall discharge flow rate (mean and standard deviation)	4R model (data from 1960 to 2013) using estimated daily discharge rates. Use of these data will not include the maximum flows from the extreme storm events which would last for less than one day.	Appendix D8-7 (Application Reference Number: 6.4.32)
Outfall discharge concentration (mean and standard deviation)	Cleaned up leachate data	Provided in this report
Upstream river flow rate (mean and Q_{95})	4R model (data from 1960 to 2013)	Appendix D8-7 (Application Reference Number: 6.4.32)
Upstream river quality (mean and standard deviation)	Monitoring provided in surface water baseline report	Appendix D8-1 (Application Reference Number: 6.4.26)
River quality target downstream of discharge	EQSs	See appendix C

Table 6.7 Summary of RQP model results (see appendix G for full results) – Test 1 Predicted concentration risk to EQS

Discharge Point	Substance	AA EQS (µg/l)	Mean predicted concentration in receiving stream (µg/l)	Mean discharge concentration required to ensure AA EQS in receiving stream is not breached (µg/l)
Annual average discharges				
B1 (Tre'r Gof - upstream)	Orthophosphate (as P)	78	**125**	80
	Copper (bioavailable)	1.0	0.23	1.1
	Chromium (III)	4.7	1.56	5.15
	Iron (dissolved)	1,000	367	1,129
	Lead (bioavailable)	1.2	0.60	1.4
	Anionic Polyelectrolyte	7,500	870	8,619
C1 (Nant Caerdegog Isaf - Afon Cafnan tributary)	Orthophosphate (as P)*	78	**107**	75
	Nitrate (as NO_3)	50,000	11,241	91,850
	Copper (bioavailable)	1.0	0.16	1.9
	Chromium (III)	4.7	1.42	8.1
	Lead (bioavailable)	1.2	0.35	2.4
	Zinc (bioavailable)	13.9	2.84	11.1
	Anionic Polyelectrolyte	7,500	497	15,078
A3 (Nant Cemaes)	Orthophosphate (as P)*	78	**84**	44
	Lead (bioavailable)	1.2	0.07	17
A1 (Tre'r Gof - downstream)	Orthophosphate (as P)	78	**103**	88
	Lead (bioavailable)	1.2	0.39	2.1
Discharge Point	**Substance**	**MAC EQS (µg/l)**	**95%ile predicted concentration in receiving stream (µg/l)**	**Mean discharge concentration required to ensure MAC EQS in receiving stream is not breached (µg/l)**
Short term discharges				
B1 (Tre'r Gof - upstream)	Lead (dissolved)	14.0	**21**	4.4
C1 (Nant Caerdegog Isaf - Afon Cafnan tributary)	Lead (dissolved)	14.0	13	7.0
A3 (Nant Cemaes)	Lead (dissolved)	14.0	3.9	49

Results in bold show exceedance of the EQS
* For these discharges the mean upstream orthophosphate concentration already exceeds the EQS. The mean discharge concentration required to ensure the AA EQS is not breached is effectively showing the concentration in the discharge that would be required to dilute the upstream concentration to the EQS in the receiving watercourse.

Test 1 of the assessment shows that for the majority of discharges and substances, the concentration in the discharge does not cause the AA EQS to be exceeded. However, for orthophosphate the AA EQS is exceeded in all catchments. However, in some cases the upstream concentration already exceeds the EQS. The modelling predicts that in all cases the average discharge concentration required in order for the EQS not to be breached is exceeded by the predicted discharge concentration from the leaching tests.

Dissolved lead concentrations in the discharges from outfall B1 (Tre'r Gof) also causes the predicted 95th percentile concentrations in the watercourse to exceed the MAC EQS for short term discharges.

Table 6.8 Summary of RQP model results – Test 2 Deterioration of receiving water quality

Discharge Point	Substance	AA EQS (µg/l)	Mean upstream quality (µg/l)	Upstream concentration + 10% of EQS (µg/l)	Mean predicted concentration in receiving stream (µg/l)
Annual average discharges					
B1 (Tre'r Gof - upstream)	Orthophosphate (as P)	78	62	70	**125**
	Copper (bioavailable)	1	0.05	0.15	**0.23**
	Chromium (III)	4.7	1.53	2.0	1.6
	Iron (dissolved)	1000	110	210	**367**
	Lead (bioavailable)	1.2	0.01	0.13	**0.60**
	Anionic Polyelectrolyte	7500	0	750	**870**
C1 (Nant Caerdegog Isaf - Afon Cafnan tributary)	Orthophosphate (as P)	78	80	88	**107**
	Nitrate (as NO_3)	50,000	6980	11980	11241
	Copper (bioavailable)	1	0.06	0.16	0.16
	Chromium (III)	4.7	1.27	1.7	1.4
	Lead (bioavailable)	1.2	0.01	0.13	**0.35**
	Zinc (bioavailable)	13.9	1.99	3.4	2.8
	Anionic Polyelectrolyte	7500	0	750	497
A3 (Nant Cemaes)	Orthophosphate (as P)	78	80	88	84
	Lead (bioavailable)	1.2	0.02	0.14	0.07
A1 (Tre'r Gof - downstream)	Orthophosphate (as P)	78	62	70	**103**
	Lead (bioavailable)	1.2	0.01	0.13	0.39
Discharge Point	**Substance**	**MAC EQS (µg/l)**	**Mean upstream quality (µg/l)**	**Upstream concentration + 10% of EQS (µg/l)**	**95%ile predicted concentration in receiving stream (µg/l)**
Short term discharges					
B1 (Tre'r Gof - upstream)	Lead (dissolved)	14.0	1.39	2.8	**21**
C1 (Nant Caerdegog Isaf - Afon Cafnan tributary)	Lead (dissolved)	14.0	1.39	2.8	13
A3 (Nant Cemaes)	Lead (dissolved)	14.0	1.27	2.7	3.9

Results in bold show where the predicted mean downstream concentration leads to deterioration of more than 10% of the EQS

For Test 2, the assessment shows that certain discharges do cause a deterioration of water quality of greater than 10% of the AA EQS. These are for orthophosphate, bioavailable copper, iron, bioavailable lead and polyelectrolyte at B1 (which ultimately discharges through Tre'r Gof SSSI); orthophosphate and bioavailable lead at C1 (Nant Caerdegog Isaf); orthophosphate at A1 (Tre'r Gof downstream) and the MAC for dissolved lead at B1 (compared to the 95%ile). In the case of the B1 discharge it should also be noted that (as discussed previously) the discharges are expected to pass though drainage channels within the Tre'r Gof SSSI with minimal interaction with the fen within the SSSI.

6.4 Modelling of marine discharges

6.4.1 Results from Test 1

The results of Test 1 indicated that there are substances which would be discharged into marine waters that will require further consideration. The relevant EQSs and predicted discharge concentrations are presented in table 6.9.

Table 6.9 Predicted discharge concentrations* into marine waters

Marine discharge / outfall point and receiving water	Discharge /outfall number and pathway to discharge point	Copper (dissolved) (µg/l)	Lead (dissolved) (µg/l)	Zinc (dissolved) (µg/l)	Nickel (dissolved) (µg/l)
EQS (Annual Average)		3.76	1.3	7.9	8.6
EQS (Maximum Allowable Concentration)		n/a	14	n/a	34
Surface water discharges					
1S - Cemaes Bay	A3 via Nant Cemaes	4.31	2.85	Not exceeded	Not exceeded
A2 – Cemaes Bay	A2 direct to sea	9.3	6.5	11	Not exceeded
2S - Porth y Wylfa	A1 and B1 via Tre'r Gof channel	9.25	6.50	11.40	Not exceeded
PB and PC (surface water) - Porth-y-pistyll (direct to sea)	PB/PC direct to sea	9.3	6.5	11	Not exceeded
3S – Porth-y-pistyll	C1, D1, D2 and E1 via Afon Cafnan	8.53	5.95	10.90	Not exceeded
Groundwater discharges					
PB and PC (groundwater) - Porth-y-pistyll (direct to sea)	PB/PC direct to sea	Not exceeded	Not exceeded	38	17

*Predicted discharge concentrations to the marine environment for the streams used the PEC were calculated from the freshwater H1 assessment undertaken in 2017 for the most downstream point of any particular watercourse. Groundwater discharge concentrations are as shown in appendix A, table 2.

6.4.2 Modelling methodology

Horizon developed a marine hydrodynamic model [RD11] to aid understanding of the potential influence of the structures and discharges associated with the Power Station on the marine environment during construction and operation. The model simulated the marine environment around the Wylfa Newydd Development Area and was used to predict the effects from discharges during construction on the surrounding waters. The model was based on the Dutch Continental Shelf Model, developed by Deltares, which included the Irish Sea and has been used extensively to model marine and coastal infrastructure developments. The model utilised bathymetric (depth of the seabed) data collected during targeted surveys and from marine charts. Model runs simulated one complete spring-neap tidal cycle and the values taken a proxy annual average which could be compared with the AA EQSs for each substance. Modelling was based on a worst case scenario which assumed the following:

- All discharges from sediment settlement ponds would occur at the same time. In reality the removal of topsoil, bulk earthworks, dewatering and mound creation would be phased and works would be carried out in different areas and times during construction across the Wylfa Newydd Development Area. In addition, once completed, or dormant, mounds would be grassed to limit sediment mobilisation.

- The predicted concentration at the point furthest downstream is the same as the concentration that would enter the sea. In reality for three of the five discharges there would be further dilution in the streams prior to reaching the sea. Only A2, PB and PC discharge directly into the sea.
- The modelling scenario used 1 in 2 year storm event, with a 1 in 30 year storm event (lasting for a duration of 24 hours) randomly assigned within the modelling period. The results and corresponding averages were then compared against an AA.

6.4.3 Modelling results

The assumed flows are presented in tables 6.10 to 6.18. Due to the unknown phasing of the works, the concentrations of individual discharges are presented in tables 6.10 to 6.18 which include instantaneous maxima and highest average concentrations of individual discharges as well as the area over which the average concentration is in exceedance of the AA EQS. However, even with discharges occurring in-combination, it is expected that there would be no significant difference in the mixing zones[1] for each metal.

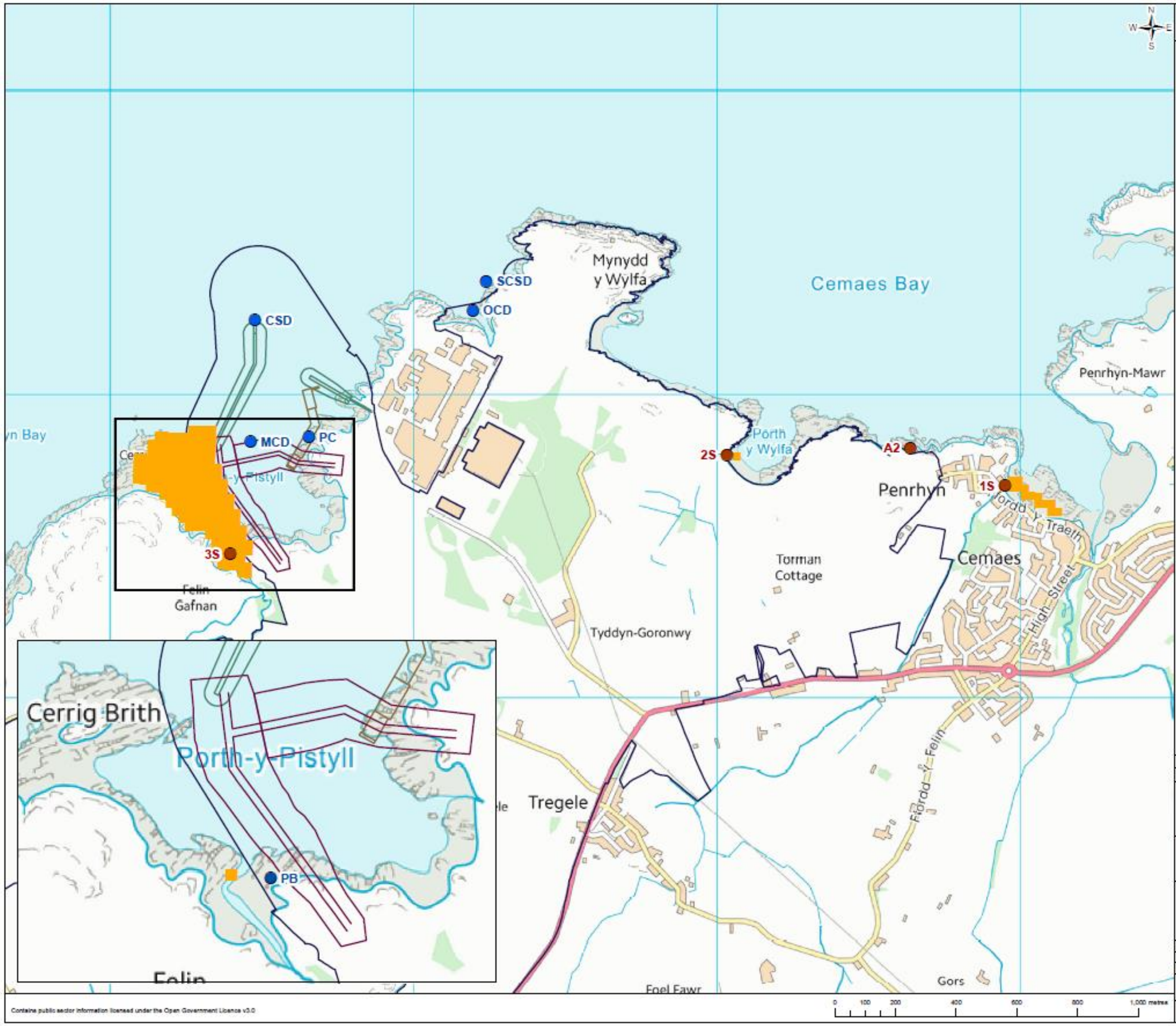
The modelling outputs were as follows:

- For dissolved zinc the maximum concentration occurred at marine discharge point 2S (11.39µg/l) downstream of A1 and B1 via the Tre'r Gof channel. However, the zinc AA EQS was not exceeded for any of the discharges' average concentrations in the receiving waters.
- For dissolved lead the maximum concentration also occurred at marine discharge point 2S (6.49µg/l) downstream of A1 and B1 via the Tre'r Gof channel. The dissolved lead AA EQS was exceeded by the average discharge concentration within four areas. These areas were in the proximity of discharges 1S, 2S, 3S and PB, with 3S having the largest mixing zone. The overall area exceeding the AA EQS totalled 10.10ha; see figure 6.1 and tables 6.10 to 6.18).
- For dissolved copper the maximum concentration also occurred at marine discharge point 2S (9.24µg/l) downstream of A1 and B1 via the Tre'r Gof channel. The dissolved copper AA EQS was exceeded by the average discharge concentration within an overall area of 0.42ha (within close proximity to discharge point 3S and PB).
- For dissolved nickel the maximum concentration occurred at PB (4.54µg/l). However, the nickel AA EQS was not exceeded for any of the discharges' average or maximum concentrations in the receiving waters.

As a worst case, the maximum concentration data for each substance was compared against the corresponding AA EQS. For dissolved zinc, the AA EQS is exceeded by the maximum concentration data within an overall area of 2.01ha in the model. For dissolved lead, the AA EQS is exceeded by the maximum concentration data within an overall area of 31.05ha in the model. For dissolved copper, the AA EQS is exceeded by the maximum concentration data within an overall area of 11.96ha in the model.

[1] Under the EQS Directive, the mixing zone is "that part of a body of surface water restricted to the proximity of the discharge within which the Competent Authority is prepared to accept EQS exceedance, provided that it does not affect the compliance of the rest of the water body with the EQS".

FIGURE 6-1



Legend

- Wylfa Newydd Development
- Breakwaters
- Marine off-loading facility
- Temporary cofferdam and causeway
- Marine outfall point
- Marine discharge point
- Predicted average lead concentration above EQS

Current EQS for lead is 1.3µg/l as annual average and 14µg/l as a maximum allowable concentration

Notes:
CSD: Construction sewage discharge
MCD: Main cofferdam dewatering
OCD: Outfall cofferdam dewatering
SCSD: Site campus sewage discharge (Dŵr Cymru Welsh Water)

0	FEB 18	Initial issue	VG	IL-E	MR	RB
Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd

Client

HORIZON NUCLEAR POWER

Project

WYLFA NEWYDD PROJECT
CONSTRUCTION H1 ASSESSMENT

Drawing Title

PREDICTED DILUTION OF DISSOLVED LEAD IN THE MARINE ENVIRONMENT AT SURFACE

Scale @ A3	1:12,000	DO NOT SCALE
Jacobs No.	60PO8083	
Client No.		

Drawing No. 60PO8083_HYD_REP_001_06_01

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Table 6.10 Discharge concentrations, annual average (AA) EQS, maximum and highest average concentration values and area of AA exceedance for point 1S.*=model maximum output value at or above discharge concentration (likely to be an artefact of model processing).

Contaminant	Discharge conc. (model input conc.)	AA EQS	Model outputs		
			Maximum conc.	Highest avg. conc.	Area of AA EQS exceedance (using avg. data)
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(ha)
Zinc	6.99	7.9	6.99*	3.99	n/a
Lead	2.85	1.3	2.85*	1.62	0.69
Copper	4.31	3.76	4.31*	1.46	n/a
Nickel	1.35	8.6	1.35*	0.77	n/a
Assumed flow	**1.53m³/s (1:2yr flow)**				
Assumed flow	**2.85m³/s (1:30yr flow - 24hr only)**				

Table 6.11 Discharge concentrations, annual average (AA) EQS, maximum and highest average concentration values and area of AA exceedance for point 2S.

Contaminant	Discharge conc. (model input conc.)	AA EQS	Model outputs		
			Maximum conc.	Highest avg. conc.	Area of AA EQS exceedance (using avg. data)
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(ha)
Zinc	11.40	7.9	11.39	2.38	n/a
Lead	6.50	1.3	6.49	1.36	0.05
Copper	9.25	3.76	9.24	1.93	n/a
Nickel	1.61	8.6	1.61	0.33	n/a
Assumed flow	**0.50m³/s (1:2yr flow)**				
Assumed flow	**0.80m³/s (1:30yr flow - 24hr only)**				

Table 6.12 Discharge concentrations, annual average (AA) EQS, maximum and highest average concentration values and area of AA exceedance for point 3S. *=model maximum output value at or above discharge concentration (likely to be an artefact of model processing).

Contaminant	Discharge conc. (model input conc.)	AA EQS	Model outputs		
			Maximum conc.	Highest avg. conc.	Area of AA EQS exceedance (using avg. data)
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(ha)
Zinc	10.90	7.9	10.90*	6.1	n/a
Lead	5.95	1.3	5.95*	3.33	9.31
Copper	8.53	3.76	8.53*	4.78	0.37
Nickel	1.58	8.6	1.58*	0.88	n/a
Assumed flow	**5.62m³/s (1:2yr flow)**				

Contaminant	Discharge conc. (model input conc.)	AA EQS	Model outputs		
			Maximum conc.	Highest avg. conc.	Area of AA EQS exceedance (using avg. data)
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(ha)
Assumed flow	7.83m³/s (1:30yr flow - 24hr only)				

Table 6.13 Discharge concentrations, annual average (AA) EQS, maximum and highest average concentration values and area of AA exceedance for point A2.

Contaminant	Discharge conc. (model input conc.)	AA EQS	Model outputs		
			Maximum conc.	Highest avg. conc.	Area of AA EQS exceedance (using avg. data)
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(ha)
Zinc	11.4	7.9	0.06	0.01	n/a
Lead	6.45	1.3	0.03	0.01	n/a
Copper	9.3	3.76	0.05	0.01	n/a
Nickel	1.61	8.6	0.01	<0.01	n/a
Assumed flow	0.0009m³/s (Average flow)				
Assumed flow	0.146m³/s (1:30yr flow - 24hr only)				

Table 6.14 Discharge concentrations, annual average (AA) EQS, maximum and highest average concentration values and area of AA exceedance for Main cofferdam discharge (GW only).

Contaminant	Discharge conc. (model input conc.)	AA EQS	Model outputs		
			Maximum conc.	Highest avg. conc.	Area of AA EQS exceedance (using avg. data)
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(ha)
Zinc	37.76	7.9	0.77	0.58	n/a
Lead	1	1.3	0.02	0.02	n/a
Copper	1.32	3.76	0.03	0.02	n/a
Nickel	16.52	8.6	0.34	0.25	n/a
Assumed flow	0.0023m³/s				

Table 6.15 Discharge concentrations, annual average (AA) EQS, maximum and highest average concentration values and area of AA exceedance for point PBGW.

Contaminant	Discharge conc. (model input conc.)	AA EQS	Model outputs		
			Maximum conc.	Highest avg. conc.	Area of AA EQS exceedance (using avg. data)
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(ha)
Zinc	37.76	7.9	10.38	6.84	n/a

Lead	1	1.3	0.27	0.18	n/a
Copper	1.32	3.76	0.36	0.24	n/a
Nickel	16.52	8.6	4.54	3	n/a
Assumed flow	**0.0014m³/s**				

Table 6.16 Discharge concentrations, annual average (AA) EQS, maximum and highest average concentration values and area of AA exceedance for point PBSW.

Contaminant	Discharge conc. (model input conc.)	AA EQS	Model outputs		
			Maximum conc.	Highest avg. conc.	Area of AA EQS exceedance (using avg. data)
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(ha)
Zinc	11.4	7.9	11.19	No data	No data
Lead	6.45	1.3	6.33	4.18	0.053
Copper	9.3	3.76	9.13	6.03	0.053
Nickel	1.61	8.6	1.58	7.39	n/a
Assumed flow	**0.005m³/s (average flow)**				
Assumed flow	**1.174m³/s (1:30yr flow - 24hr only)**				

Table 6.17 Discharge concentrations, annual average (AA) EQS, maximum and highest average concentration values and area of AA exceedance for point PCGW.

Contaminant	Discharge conc. (model input conc.)	AA EQS	Model outputs		
			Maximum conc.	Highest avg. conc.	Area of AA EQS exceedance (using avg. data)
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(ha)
Zinc	37.76	7.9	0.3	0.2	n/a
Lead	1	1.3	0.01	0.01	n/a
Copper	1.32	3.76	0.01	0.01	n/a
Nickel	16.52	8.6	0.13	0.09	n/a
Assumed flow	**0.0014m³/s**				

Table 6.18 Discharge concentrations, annual average (AA) EQS, maximum and highest average concentration values and area of AA exceedance for point PCSW.

Contaminant	Discharge conc. (model input conc.)	AA EQS	Model outputs		
			Maximum conc.	Highest avg. conc.	Area of AA EQS exceedance (using avg. data)
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(ha)
Zinc	11.4	7.9	0.12	0.08	n/a
Lead	6.45	1.3	0.07	0.05	n/a
Copper	9.3	3.76	0.1	0.07	n/a

Contaminant	Discharge conc. (model input conc.)	AA EQS	Model outputs		
			Maximum conc.	Highest avg. conc.	Area of AA EQS exceedance (using avg. data)
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(ha)
Nickel	1.61	8.6	0.02	0.01	n/a
Assumed flow	**0.005m^3/s (average flow)**				
Assumed flow	**1.174m^3/s (1:30yr flow - 24hr only)**				

7. Summary

This report has been produced as an assessment of the effects of surface water discharges associated with construction work for the Wylfa Newydd Project. As these are discharges yet to be established, the potential effect has utilised data from leaching tests of shallow soils from the site, results of surface water monitoring, results of pumping tests and modelling results of surface water and drainage flows. This report has presented screening and modelling of potential effects to freshwater and marine waters so that NRW can determine appropriate discharge limits for the Environmental Permit.

The H1 assessment methodology does not deal with suspended solids and therefore does not provide information with which to consider limits for this parameter.

7.1 Effects on freshwaters

For freshwaters the screening assessment indicates that the effects of certain metals, orthophosphate, polyelectrolyte and PAHs are potentially significant and need to be considered further. These determinands have therefore been carried over to the modelling stage of the assessment.

Following an assessment of whether the discharges are liable to contain a substance and clean-up of data to adjust detection limits and removal of outliers, modelling of the discharges to freshwater has been undertaken for bioavailable copper, lead and zinc and dissolved chromium (III), iron, lead, orthophosphate, nitrate and polyelectrolyte. This further modelling was undertaken using the Monte Carlo RQP model which takes into account the distribution of flows and quality in the discharge and receiving water and calculates the probability of concentrations in the receiving watercourse exceeding a particular value.

The results of the RQP modelling predict that the annual average EQS for orthophosphate is likely to be exceeded in the receiving waters downstream of the discharges in all watercourses. However, in some cases the upstream concentration already exceeds the EQS and in these cases the discharge itself would not cause the breach of the EQS. No other annual average EQS are predicted to be exceeded.

For Test 2 of the modelling assessment, the RQP modelling predicts that the downstream quality may deteriorate by more than 10% of the AA EQS for orthophosphate, bioavailable copper, iron and bioavailable lead in the Tre’r Gof SSSI drains; orthophosphate and bioavailable lead in Nant Caerdegog Isaf; and orthophosphate at the Tre’r Gof SSSI discharge.

Anionic polyelectrolyte carry-over also potentially causes the downstream quality to deteriorate by slightly more than 10% of the AA EQS in the Tre’r Gof SSSI drains. However, this is based on a conservative assumption of continuous dosage at the maximum planned rate and takes no account of polyelectrolyte that would be lost through binding to suspended solids in the discharge and streams. Therefore polyelectrolyte is not expected to cause a deterioration of the EQS by more than 10% at the planned dosage rate.

With respect to exceedances of short-term EQSs, only lead shows as being potentially significant as identified from the screening assessment and clean-up of data. The RQP model output predicts that the 95th percentile concentration resulting from discharges at outfall B1 exceeds the short term MAC EQS for dissolved lead.

7.2 Effects on marine waters

Test 1 of the Phase 1 assessment (comparing predicted discharge concentrations to the marine EQS) identifies that certain metals and PAHs could potentially be discharged at significant concentrations. Following clean-up of the input data, it was determined that effects of the discharges on marine waters from dissolved copper, lead, zinc and nickel may be significant and required further modelling.

Modelling was carried out for copper, lead, nickel and zinc using the Delft3d model developed for the project. The modelling predicted all concentrations of dissolved nickel would be below the AA EQS. For copper, zinc and lead the predicted maximum concentrations are all above the relevant AA EQSs. The highest concentrations of these metals all occur at marine discharge point 2S, downstream of Tre-r Gof. However, the only average concentrations to exceed the AA EQS were for copper (at 3S and PB) and lead (at 1S, 2S, 3S and PB) . When interpreting the mixing zones areas, it should be borne in mind that the flow data reflects peak storm flows and therefore a worst case (i.e. representing an event rather than a sustained average flow).

The predicted mixing zones are therefore considered precautionary and would not persist in the long-term as soil stripping, earthworks, dewatering and mound creation would be carried out in different areas at different times across the Wylfa Newydd Development Area; with mounds being reseeded when left dormant or when work is complete, therefore reducing the leaching of substances from the soil (see section 13.6 in chapter D13 (the marine environment) (Application Reference Number: 6.4.13)). In addition, the predicted average data are based on extreme, high flow scenarios which would again constitute a worst case owing to the relatively high volumes discharged.

8. References

ID	Reference
RD1	https://naturalresources.wales/permits-and-permissions/environmental-permits/horizontal-guidance/?lang=en [accessed May 2017]
RD2	https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit [accessed May 2017]
RD3	Natural Resources Wales. 2014. How to comply with your Environmental Permit. Additional guidance for: Water Discharge and Groundwater (from point source) Activity Permits. EPR 7.01, Version 5.0, October 2014.
RD4	Structural Soils. 2016. *Interpretative report for Task Order 001 – PW1 Pump Test*. Structural Soils Limited, Report No. 70398, April 2016.
RD5	Structural Soils. 2016. *Interpretative report for Task Order 001 - PW2 Pump Test*. Structural Soils Limited, Report No. 70398, April 2016.
RD6	United Kingdom Technical Advisory Group (UKTAG). 2014. *River & Lake Assessment Method Specific Pollutants (Metals). Metal Bioavailability Assessment Tool (M-BAT).*
RD7	Structural Soils. 2016. Task Order 7: *SP&C Jar & Liquor Testing - Factual Report* on Laboratory Testing.
RD8	Amec Foster Wheeler. 2017, Main Site Construction Foul Water Design Report. WN0902-HZCON-EPT-REP-00001. A report for Horizon Nuclear Power.
RD9	http://evidence.environment-agency.gov.uk/ChemicalStandards/home.aspx [accessed May 2017]
RD10	Environment Agency. 2014. LIT 10419, *Modelling: surface water pollution risk assessment.*
RD11	Horizon. 2012. *Wylfa Hydrodynamic and Water Quality Modelling: Phase 2 model build, Calibration and Validation* (WYL-PD-PAC-REP-00015).

Appendices

Appendix A - Discharge Quality Data

Appendix A Table 1 - Surface water discharge concentrations

Substance	No. leaching test results used to calculate mean concentration	No. of results less than the limit of detection	Mean dissolved concentration from leaching tests in top 0.5m (ug/l)
Chloride	20	1	4780
Sulphate	38	12	17620
Suspended solids	n/a	n/a	0
Ammoniacal nitrogen	50	35	175
Phosphate (orthophosphate) as P	38	23	138
Nitrate (as NO3)	50	8	15036
Sodium	8	0	9130
Calcium	8	0	13710
Potassium	38	20	2840
Metals			
Antimony	2	0	7.5
Arsenic	48	32	1.67
Boron	76	18	24.81
Cadmium	76	71	0.59
Cobalt	46	42	1
Copper (dissolved)	78	1	9.26
Copper (bioavailable)	78	1	0.35
Chromium (III)	78	31	2.02
Iron	38	14	395
Lead (dissolved)	78	14	13
Lead (bioavailabe)	78	14	1.44
Magnesium	8	1	4
Manganese (dissolved)	64	2	62.4
Manganese (bioavailable)	64	2	20
Mercury	46	44	0.09
Molybdenum	26	20	1.46
Nickel (dissolved)	78	26	1.61
Nickel (bioavailable)	78	26	0.29
Selenium	46	46	1
Vanadium	20	13	1.20
Zinc (dissolved)	78	4	14.1
Zinc (bioavailable)	78	4	4.38
Organics			
Total petroleum hydrocarbons	46	42	13.7
Trichloroethene			0
Anthracene	48	45	0.023
Benzo(a)pyrene	48	47	0.021
Benzo(b)fluoranthene	48	46	0.021
Benzo(k)fluoranthene	48	47	0.02
Benzo(g,h,i)-perylene	48	46	0.028
Fluoranthene	48	46	0.02
Naphthalene	48	44	0.082
Phenol	10	9	2.2

Appendix A Table 2 - Groundwater discharge concentrations

Substance	No. sample test results used to calculate mean concentration	No. of results less than the limit of detection	Mean concentration (ug/l)
Sulphate (w)	23	0	30348
Cyanide (total) (w)	23	23	6.304
Metals			
Arsenic (dissolved)	24	24	1.00
Boron (dissolved)	24	0	30.96
Cadmium dissolved 0.05ug/l)	24	24	0.05
Copper (dissolved)	25	15	1.32
Chromium (dissolved)	25	23	1.48
Chromium (VI)	23	23	52.17
Iron (dissolved)	24	12	36.13
Lead (dissolved)	25	25	1.00
Manganese (dissolved)	25	5	102
Mercury (dissolved 0.05ug/l)	25	25	0.05
Nickel (dissolved)	25	5	16.52
Selenium (dissolved)	25	25	1.00
Vanadium (dissolved)	23	22	1.00
Zinc (dissolved)	25	0	37.76
Organics			
TPH Total Dissolved >C6-C40	9	9	50.00
Anthracene (w)	25	24	0.61
Benzo(a)pyrene (w)	25	24	0.61
Benzo(b)fluoranthene (w)	25	24	0.61
Benzo(k)fluoranthene (w)	25	24	0.61
Benzo(ghi)perylene (w)	25	24	0.61
Fluoranthene (w)	25	21	0.61
Naphthalene (w)	25	13	0.64
Phenol	25	17	1.16
Hexachlorobenzene	25	25	1.00
Hexachlorobutadiene	25	25	1.00
Indeno(123-cd)pyrene (w)	25	24	0.61

PAH total		3.05

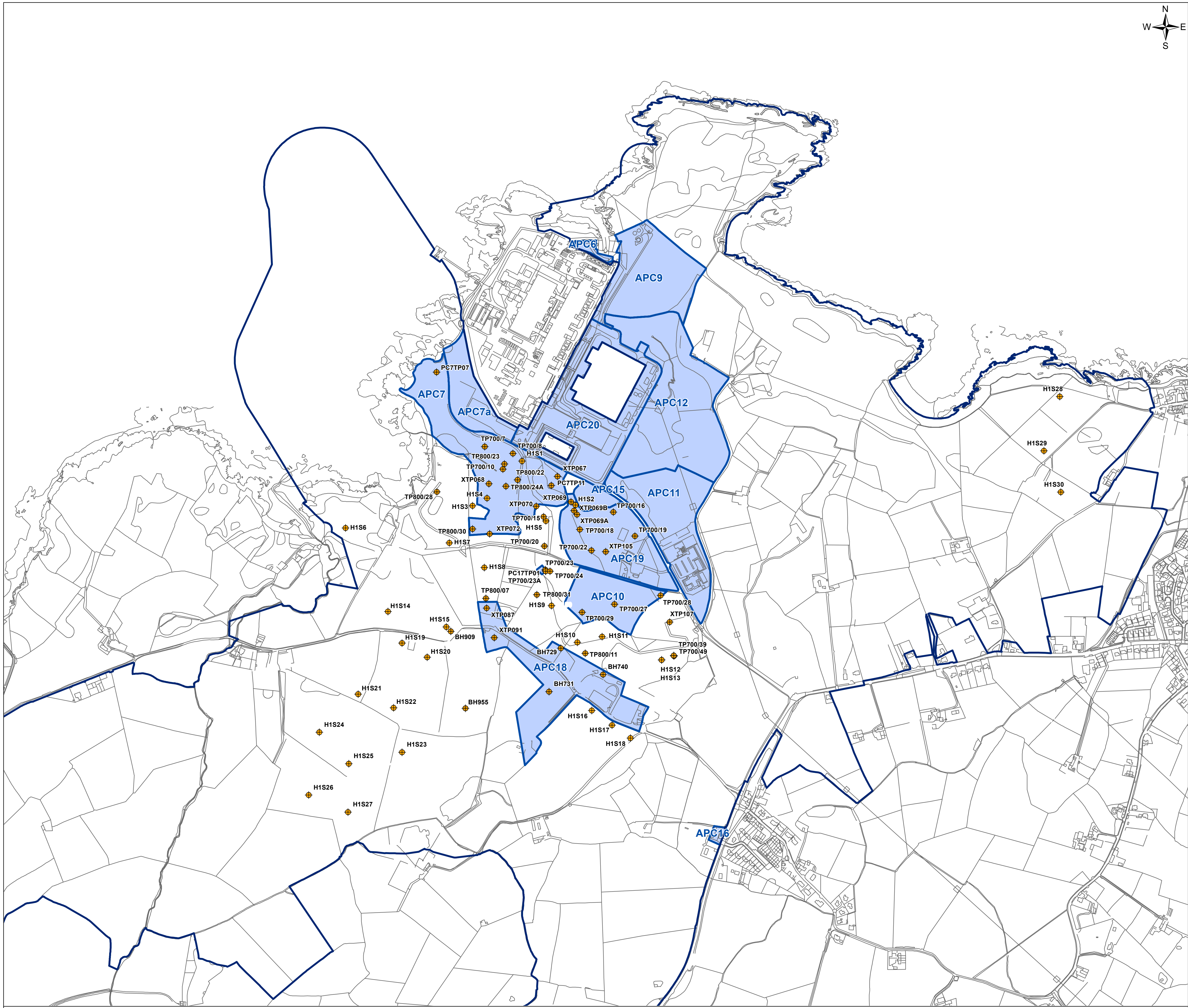
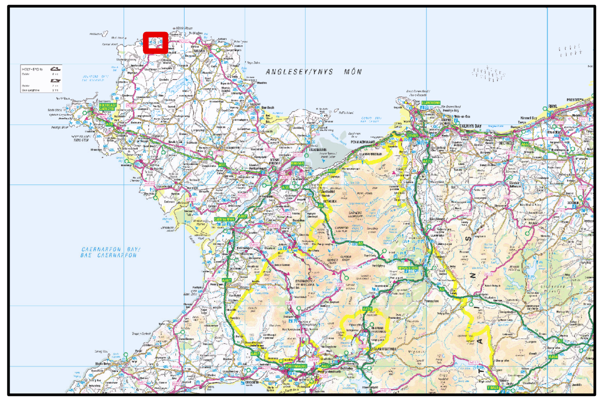


FIGURE A1

Legend

- Wylfa Newydd Development Area
- Location of leaching test result used in H1 Assessment
- Areas of Potential Concern



Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
1.0	MAR 18	DCO submission	HNPWL	HNPWL	HNPWL	HNPWL

Client

HORIZON NUCLEAR POWER

Project

WYLFA NEWYDD PROJECT
ENVIRONMENTAL PERMIT

Drawing Title

CONSTRUCTION H1 ASSESSMENT
SOIL SAMPLE SITES AND AREAS OF POTENTIAL CONCERN

Scale @ A3	1:10,000	DO NOT SCALE
Jacobs No.	60PO8077	
Client No.		
Drawing No.	60PO8083_HYD_REP_001001	

This drawing is not to be used in whole or in part other than for the intended purpose and project as defined on this drawing. Refer to the contract for full terms and conditions.

0 100 200 400 600 800 1,000 Metres

Appendix B - Existing Surface Water Quality Data

Appendix B Table 1 - Background Freshwater Concentrations (all results µg/l)

Discharge point:			B1		C1, D1, E1, E2, D2		A2, WP1/2/3	A3		A1, SC1	
Freshwater monitoring point:	AA EQS (ug/l)	10% of AA EQS (ug/l)	Tre'r Gof		Afon Cafnan - Caerdegog Isaf		To sea	Nant Cemaes		Tre'r Gof	
			No. samples	Mean	No. samples	Mean		No. samples	Mean	No. samples	Mean
Inorganics											
Chloride	250000	25000	90	70720	87	48010	Discharges	27	49060	90	70720
Sulphate	400000	40000	67	30610	35	17190	direct to sea	11	35880	67	30610
Total Suspended Solids	n/a	n/a	91	523970	85	94730		27	15460	91	523970
Ammoniacal nitrogen as N	600	60	90	220	85	250		22	110	90	220
Phosphate (ortho) as P	78	7.8	61	62	70	80		21	83	61	62
Nitrate (as NO3)	50000	5000	67	13250	35	6980		11	9522	67	13250
Sodium (dissolved)			65	35360	38	26990		11	32240	65	35360
Calcium (dissolved)			77	44800	38	34360		11	67430	77	44800
Potassium (dissolved)			65	4240	38	3460		11	3560	65	4240
Metals											
Antimony	113	11.3		11.3	1	0.233		5	0.57		11.3
Arsenic (dissolved)	50	5	34	0.85	83	1.42		27	0.98	34	0.85
Boron	2000	200		200		200			200		200
Cadmium (dissolved)	0.09	0.009	34	0.10	83	0.13		27	0.10	34	0.10
Cobalt	3	0.3		0.30		0.30		5	0.16		0.30
Copper (dissolved)			34	1.59	83	2.49		27	2.16	34	1.59
Copper (bioavailable)	1	0.1	6	0.05	16	0.06		4	0.10	6	0.05
Chromium (dissolved)	4.7	0.47	22	1.53	83	1.27		27	1.21	22	1.53
Iron (dissolved)	1000	100	65	110.0	86	870		27	180.0	65	110.0
Lead (dissolved)			34	1.39	80	1.39		26	1.27	34	1.39
Lead (bioavailable)	1.2	0.12	6	0.01	16	0.010		3	0.02	6	0.01
Magnesium (dissolved)			65	10630	38	9200		11	19810	65	10630
Manganese (dissolved)			27	477.7	73	198.0		23	202.5	27	477.7
Manganese (bioavailable)	123	12.3	6	44.8	13	66.1		3	51.85	6	44.8
Mercury (dissolved)			23	0.01	83	0.01		27	0.01	23	0.01
Molybdenum	12700	1270		1270		1270			1270		1270
Nickel (dissolved)			34	1.01	80	1.33		26	1.24	34	1.01
Nickel (bioavailable)	4	0.4	6	0.25	13	0.33		3	0.37	6	0.25
Selenium (dissolved)	2	0.2	11	0.76	35	0.70		11	0.91	11	0.76
Vanadium	20	2		2		2			2		2
Zinc (dissolved)			34	6.99	82	6.78		27	5.08	34	6.99
Zinc (bioavailable)	13.9	1.39	6	4.18	16	1.99		4	1.07	6	4.18
Organics											
Total petroleum hydrocarbons	250	25		25		25			25		25
Anthracene	0.1	0.01		0.01		0.01			0.01		0.01
Benzo(a)pyrene	0.00017	0.000017		0.000017		0.000017			0.000017		0.000017
Benzo(b)fluoranthene	0.017	0.0017		0.0017		0.0017			0.0017		0.0017
Benzo(k)fluoranthene	0.017	0.0017		0.0017		0.0017			0.0017		0.0017
Benzo(g,h,i)-perylene	0.0082	0.00082		0.00082		0.00082			0.00082		0.00082
Fluoranthene	0.0063	0.00063		0.00063		0.00063			0.00063		0.00063
Naphthalene	2	0.2		0.20		0.20			0.20		0.20
Phenol (SVOC)	7.7	0.77	1	0.133	4	0.865			0.77	1	0.133

Data taken from Surface Water Baseline report (Application Reference Number: 6.4.26)

Shaded cells take 10% of EQS as no upstream data are available

Appendix C - Water Quality Standards Used in the H1 Assessment

Appendix C - EQSs used for H1 assessment

Substance	Freshwater (ug/l)		Marine (ug/l)		Source of EQS
	Long term	Short term	Long term	Short term	
Chloride	250000	NA	NA	NA	Dangerous Substances Directive
Sulphate	400000	NA	NA	NA	Dangerous Substances Directive
Ammoniacal nitrogen (as N)	600	NA	NA	NA	Water Framework Directive
Phosphorous (reactive as P)*	78	NA	NA	NA	Water Framework Directive
Nitrate (as NO_3)	50,000	NA	NA	NA	Nitrate Pollution Prevention (Wales) Regulations 2013/ Nitrates Directive. Standard for designation of nitrate pollution for fresh surface waters.
Anionic and Non-ionic Polylectrolytes	7500	NA	7500^	NA	National Resources Wales (2014) How to comply with your environmental permit. Additional guidance for: Water Discharge and Groundwater (from point source) Activity Permits. EPR 7.01, Version 5.0, October 2014.
Metals					
Antimony	113	NA	11.3	NA	Antimony PNEC from Arche, 2014. Position Paper on PBT Properties of Antimony
Arsenic	50	NA	25	NA	Water Framework Directive
Boron	2000	NA	7000	NA	Dangerous Substances Directive
Cadmium	0.09	0.6	0.2	0.6	Water Framework Directive
Cobalt	3	100	3	100	Dangerous Substances Directive
Copper (dissolved)	NA	NA	3.76	NA	Water Framework Directive
Copper (boiavailable)	1	NA	NA	NA	Water Framework Directive
Chromium	4.7	32	0.6	32	Freshwater EQS is from Water Framework Directive and for chromium (III). Marine water EQS is from Water Framework Directive and for chromium (VI)
Iron	1000	NA	1000	NA	Water Framework Directive
Lead (dissolved)	NA	14	1.3	14	Water Framework Directive
Lead (boiavailable)	1.2	NA	NA	NA	Water Framework Directive
Magnesium	NA	NA	NA	NA	No EQS or PNEC identified
Manganese (boiavailable)	123	NA	NA	NA	Water Framework Directive
Mercury	NA	0.07	NA	0.07	Water Framework Directive
Molybdenum	12,700	NA	1,920	NA	Arche, 2012. The Toxicity of Molybdate to Freshwater and Marine Organisms. II. Effects Assessment of Molybdate in the Aquatic Environment Under REACH
Nickel (dissolved)		34	8.6	34	Water Framework Directive
Nickel (boiavailable)	4	NA	NA	NA	Water Framework Directive
Selenium	2	NA	2	NA	Selenium PNEC from Sheppard et al, 2005. Ecotoxicological Probable- o- Effect Concentrations for Elements Related to Nuclear Waste (Australian Journal of Ecotoxicology, Vol 11)
Vanadium	20	NA	100	NA	Dangerous Substances Directive
Zinc (dissolved)	NA	NA	7.9	NA	Water Framework Directive
Zinc (boiavailable)	13.9	NA	NA	NA	Water Framework Directive
Organics					
Total petroleum hydrocarbons	250	NA	250	NA	Jacobs in-house assessment. The Freshwater Fish Directive refers to *"Petroleum products must not be present in the water in such quantities that they; a) form a visible film on the surface of the water of foam coatings on the beds of water courses and lakes; b) impart a detectable 'hydrocarbon' taste to fish; c) produce harmful effects on fish "*
Anthracene	0.1	0.1	0.1	0.1	Water Framework Directive
Benzo(a)pyrene	0.00017	0.27	0.00017	0.027	Water Framework Directive
Benzo(b)fluoranthene	NA	0.017	NA	0.017	Water Framework Directive for sum of benzo(b)fluoranthene and Benzo(k)fluoranthene
Benzo(k)fluoranthene	NA	0.017	NA	0.017	Water Framework Directive for sum of Benzo(b)fluoranthene and benzo(k)fluoranthene
Benzo(g,h,i)-perylene	NA	0.0082	NA	0.00082	Water Framework Directive for sum of benzo(g,h,i)-perylene and indeno(1,2,3-cd)-pyrene
Fluoranthene	0.0063	0.12	0.0063	0.12	Water Framework Directive
Naphthalene	2	130	2	130	Water Framework Directive
Phenol	7.7	46	7.7	46	Water Framework Directive

Notes for table:

NA - Non available

Dangerous Substances Directive: Council Directive on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community (Dangerous Substances Directive) - List II substances (from Environment Agency Chemical Standards database)

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

* Reactive phosphourous (orthophosphate) EQS is calculated from the equation given in the WFD Standards Directions using an elevation of 15mAOD and an alkalinity of 140mg/l

^ No marine EQS is available, therefore the freshwater value has been applied

Appendix D - H1 Assessment – Part A

Appendix D - Table 1 - Part A Test 1 Screening against EQSs

	Concentration used for long term assessment*	Concentration used for short term assessment*					Freshwater Test 1				Marine Test 1	
	Mean Discharge	Mean Discharge	Freshwater EQS (ug/l)**		10% of freshwater	10% of freshwater	Is discharge conc	Is discharge conc >	Marine EQS (ug/l)**		Is discharge conc >	Is discharge conc >
Substance	**Concentration (ug/l)**	**Concentration (ug/l)**	**AA EQS**	**MAC EQS**	**AA EQS (ug/l)**	**MAC EQS (ug/l)**	**> 10% of AA EQS?**	**10% of MAC EQS?**	**AA EQS**	**MAC EQS**	**100% of AA EQS?**	**100% of MAC EQS?**
Inorganics												
Chloride	4780	4780	250000		25000		N					
Sulphate	17620	17620	400000		40000		N					
Ammoniacal nitrogen	175	175	600		60		Y					
Phosphate (orthophosphate as P)	138	138	78		7.8		Y					
Nitrate (as NO3)	15036	15036	50000		5000		Y					
Metals												
Antimony	7.50	7.50	113		11.3		N		11.3		N	
Arsenic	1.67	1.67	50		5		N		25		N	
Boron	24.81	24.81	2000		200		N		7000		N	
Cadmium	0.59	0.59	0.09	0.6	0.009	0.06	Y	Y	0.2		Y	
Cobalt	1.00	1.00	3	100	0.3	10	Y	N	3	100	N	N
Copper (dissolved)	9.26	9.26							3.76		Y	
Copper (bioavailable)	0.35	0.35	1		0.1		Y					
Chromium (III)	2.02	2.02	4.7	32	0.47	3.2	Y	N				
Iron	395.0	395	1000		100		Y		1000		N	
Lead (dissolved)	13.00	13.00		14		1.4		Y	1.3	14	Y	N
Lead (bioavailable)	1.44	1.44	1.2		0.12		Y					
Manganese (dissolved)	62.40	62.40										
Manganese (bioavailable)	20.00	20.00	123		12.3		Y					
Mercury	0.09	0.09		0.07		0.007		Y		0.07		Y
Molybdenum	1.460	1.46	12,700		1270		N		1920		N	
Nickel (dissolved)	1.61	1.61		34		3.4		N	8.6	34	N	N
Nickel (bioavailable)	0.29	0.29	4		0.4		N					
Selenium (dissolved)	1.00	1.00	2		0.2		Y		2		N	
Vanadium	1.20	1.20	20		2		N		100		N	
Zinc (dissolved)	14.10	14.10							7.9		Y	
Zinc (bioavailable)	4.38	4.38	13.9		1.39		Y					
Organics												
Total petroleum hydrocarbons	13.70	13.70	250		25		N		250		N	
Anthracene	0.02	0.02	0.1	0.1	0.01	0.01	Y	Y	0.1	0.1	N	N
Benzo(a)pyrene	0.02	0.02	0.00017	0.27	0.000017	0.027	Y	N	0.00017	0.027	Y	N
Benzo(b)fluoranthene	0.02	0.02		0.017		0.0017		Y		0.017		Y
Benzo(k)fluoranthene	0.02	0.02		0.017		0.0017		Y		0.017		Y
Benzo(g,h,i)-perylene	0.03	0.03		0.0082		0.00082		Y		0.00082		Y
Fluoranthene	0.02	0.02	0.0063	0.12	0.00063	0.012	Y	Y	0.0063	0.12	Y	N
Naphthalene	0.08	0.08	2	130	0.2	13	N	N	2	130	N	N
Phenol	2.20	2.20	7.7	46	0.77	4.6	Y	N	7.7	46	N	N
Anionic Polyelectrolyte	1000	1000	7500		750		Y		7500		N	

* The concentrations are the mean dissolved concentrations from the leaching test in the top 0.5 m of soil, as presented in Appendix A
** See Appendix C for source of EQSs

Appendix D - Table 2 - Part A Test 2 Calculation of Freshwater Process Contribution

		Calculation of PC for Annual Average (ug/l)									Calculation of PC for MAC (ug/l)							
Discharge point		B1	C1	D1	E2	D2	E1	A3	A1+SC1		B1	C1	D1	E2	D2	E1	A3	A1+SC1
Discharge flow rate (m^3/s)		0.00410	0.002477	0.00049	0.00170	0.00106	0.00221	0.00116	0.00606		0.527	0.924	0.178	0.77	0.419	0.961	0.274	0.787
Receiving water Q95 flow rate (m^3/s)	Test 2 Required for AA?	0.00003	0.000417	0.01743	0.01766	0.01758	0.0180	0.00267	0.000517	Test 2 Required for MAC?	0.00003	0.000417	0.01743	0.01766	0.01758	0.01795	0.00267	0.0005
Inorganics																		
Chloride	N																	
Sulphate	N																	
Ammoniacal nitrogen	Y	173.53	149.80	4.75	15.38	9.99	19.19	52.87	161.24									
Phosphate (orthophosphate as P)	Y	136.84	118.13	3.74	12.13	7.88	15.13	41.69	127.15									
Nitrate (as NO3)	Y	14909.65	12870.82	407.95	1321.15	858.67	1648.72	4542.60	13853.84									
Metals																		
Antimony	N																	
Arsenic	N																	
Boron	N																	
Cadmium	Y	0.59	0.51	0.02	0.05	0.03	0.06	0.18	0.54	Y	0.59	0.59	0.54	0.58	0.57	0.58	0.58	0.59
Cobalt	Y	0.99	0.86	0.03	0.09	0.06	0.11	0.30	0.92	N								
Copper (dissolved)																		
Copper (bioavailable)	Y	0.35	0.30	0.01	0.03	0.02	0.04	0.11	0.32									
Chromium (III)	Y	2.00	1.73	0.05	0.18	0.12	0.22	0.61	1.86	N								
Iron	Y	391.7	338.1	10.7	34.7	22.6	43.3	119.3	363.9									
Lead (dissolved)										Y	13.00	12.99	11.84	12.71	12.48	12.76	12.87	12.99
Lead (bioavailable)	Y	1.43	1.23	0.04	0.13	0.08	0.16	0.44	1.33									
Manganese (dissolved)																		
Manganese (bioavailable)	Y	19.83	17.12	0.54	1.76	1.14	2.19	6.04	18.43									
Mercury										Y	0.09	0.09	0.08	0.09	0.09	0.09	0.09	0.09
Molybdenum	N																	
Nickel (dissolved)										N								
Nickel (bioavailable)	N																	
Selenium (dissolved)	Y	0.99	0.86	0.03	0.09	0.06	0.11	0.30	0.92									
Vanadium	N																	
Zinc (dissolved)																		
Zinc (bioavailable)	Y	4.34	3.75	0.12	0.38	0.25	0.48	1.32	4.04									
Organics																		
Total petroleum hydrocarbons	N	13.58	11.73	0.37	1.20	0.78	1.50	4.14	12.62									
Anthracene	Y	0.023	0.020	0.001	0.002	0.001	0.003	0.007	0.021	Y	0.023	0.023	0.021	0.022	0.022	0.023	0.023	0.023
Benzo(a)pyrene	Y	0.021	0.018	0.001	0.002	0.001	0.002	0.006	0.019	N								
Benzo(b)fluoranthene										Y	0.021	0.021	0.019	0.021	0.020	0.021	0.021	0.021
Benzo(k)fluoranthene										Y	0.020	0.020	0.018	0.020	0.019	0.020	0.020	0.020
Benzo(g,h,i)-perylene										Y	0.028	0.028	0.026	0.027	0.027	0.027	0.028	0.028
Fluoranthene	Y	0.020	0.017	0.001	0.002	0.001	0.002	0.006	0.018	Y	0.020	0.020	0.018	0.020	0.019	0.020	0.020	0.020
Naphthalene	N									N								
Phenol	Y	2.18	1.88	0.06	0.19	0.13	0.24	0.66	2.03	N								
Anionic Polyelectrolyte	Y	991.60	856.00	27.13	87.87	57.11	109.65	302.11	921.38									

			Test 2 - Is PC > 4% of AA EQS?								Test 2 - Is PC > 4% of MAC EQS?							
			Discharge point:								Discharge point:							
	4% of AA EQS (ug/l)	4% of MAC EQS (ug/l)	B1	C1	D1	E2	D2	E1	A3	A1+ SC1	B1	C1	D1	E2	D2	E1	A3	A1+ SC1
Inorganics																		
Chloride																		
Sulphate																		
Ammoniacal nitrogen	24		Y	Y	N	N	N	N	Y	Y								
Phosphate (orthophosphate as P)	3		Y	Y	Y	Y	Y	Y	Y	Y								
Nitrate (as NO3)	2000		Y	Y	N	N	N	N	Y	Y								
Metals																		
Antimony																		
Arsenic																		
Boron																		
Cadmium	0.004	0.024	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cobalt	0.120		Y	Y	N	N	N	N	Y	Y								
Copper (dissolved)																		
Copper (bioavailable)	0.04		Y	Y	N	N	N	N	Y	Y								
Chromium (III)	0.19		Y	Y	N	N	N	Y	Y	Y								
Iron	40.0		Y	Y	N	N	N	Y	Y	Y								
Lead (dissolved)		0.56									Y	Y	Y	Y	Y	Y	Y	Y
Lead (bioavailable)	0.05		Y	Y	N	Y	Y	Y	Y	Y								
Manganese (dissolved)																		
Manganese (bioavailable)	4.92		Y	Y	N	N	N	N	Y	Y								
Mercury		0.0028									Y	Y	Y	Y	Y	Y	Y	Y
Molybdenum																		
Nickel (dissolved)																		
Nickel (bioavailable)																		
Selenium (dissolved)	0.08		Y	Y	N	Y	N	Y	Y	Y								
Vanadium																		
Zinc (dissolved)																		
Zinc (bioavailable)	0.56		Y	Y	N	N	N	N	Y	Y								
Organics																		
Total petroleum hydrocarbons																		
Anthracene	0.004	0.004	Y	Y	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Benzo(a)pyrene	0.00001		Y	Y	Y	Y	Y	Y	Y	Y								
Benzo(b)fluoranthene		0.0007									Y	Y	Y	Y	Y	Y	Y	Y
Benzo(k)fluoranthene		0.0007									Y	Y	Y	Y	Y	Y	Y	Y
Benzo(g,h,i)-perylene		0.0003									Y	Y	Y	Y	Y	Y	Y	Y
Fluoranthene	0.0003	0.0048	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Naphthalene																		
Phenol	0.31		Y	Y	N	N	N	N	Y	Y								
Anionic Polyelectrolyte	300.00		Y	Y	N	N	N	N	Y	Y								

Appendix D - Table 3a - Part A Test 3 Calculation of Freshwater Predicted Environmental Concentration for Annual Average

	Predicted discharge conc (ug/l)	Tre'r Gof-Upstream B1 Upstream conc (ug/l)	Tre'r Gof-Upstream B1 PEC (ug/l)	Afon Cafnan C1 Upstream conc (ug/l)	Afon Cafnan C1 PEC (ug/l)	Afon Cafnan D1 Upstream conc (ug/l)	Afon Cafnan D1 PEC (ug/l)	Afon Cafnan E2 Upstream conc (ug/l)	Afon Cafnan E2 PEC (ug/l)	Afon Cafnan D2 Upstream conc (ug/l)	Afon Cafnan D2 PEC (ug/l)	Afon Cafnan-Downstream E1 Upstream conc (ug/l)	Afon Cafnan-Downstream E1 PEC (ug/l)	Nant Cemaes A3 Upstream conc (ug/l)	Nant Cemaes A3 PEC (ug/l)	Tre'r Gof outflow A1+SC1 Upstream conc (ug/l)	Tre'r Gof outflow A1+SC1 PEC (ug/l)
Inorganics																	
Chloride																	
Sulphate																	
Ammoniacal nitrogen	175	220.0	175.4	250.0	185.8	185.8	185.5	185.5	184.6	184.6	184.0	184.0	183.0	110.0	129.6	175.4	175.0
Phosphate (orthophosphate as	138	62.0	137.4	80.0	129.6	129.6	129.9	129.9	130.6	130.6	131.0	131.0	131.8	83.0	99.6	137.4	137.9
Nitrate (as NO3)	15036	13250.0	15021.0	6980.0	13875.9	13875.9	13907.4	13907.4	14006.6	14006.6	14065.4	14065.4	14171.8	9522.0	11187.9	15021.0	15034.8
Metals																	
Antimony																	
Arsenic																	
Boron																	
Cadmium	0.59	0.10	0.6	0.13	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.10	0.2	0.6	0.6
Cobalt	1.00	0.30	1.0	0.30	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.16	0.4	1.0	1.0
Copper (dissolved)																	
Copper (bioavailable)	0.35	0.05	0.35	0.06	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.32	0.10	0.2	0.3	0.3
Chromium (III)	2.02	1.53	2.0	1.27	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.21	1.5	2.0	2.0
Iron	395.0	110.0	392.6	870.0	463.4	463.4	461.5	461.5	455.7	455.7	452.2	452.2	446.0	180.0	245.0	392.6	394.8
Lead (dissolved)																	
Lead (bioavailable)	1.44	0.01	1.43	0.01	1.2	1.2	1.2	1.2	1.3	1.26	1.27	1.27	1.29	0.02	0.4	1.43	1.4
Manganese (dissolved)																	
Manganese (bioavailable)	20.00	44.8	20.2	66.14	26.6	26.6	26.5	26.5	25.9	25.90	25.56	25.6	24.9	51.85	42.2	20.2	20.0
Mercury																	
Molybdenum																	
Nickel (dissolved)																	
Nickel (bioavailable)																	
Selenium (dissolved)	1.00	0.8	1.0	0.70	1.0	1.0	1.0	1.0	1.0	0.96	0.96	1.0	1.0	0.91	0.9	1.0	1.0
Vanadium																	
Zinc (dissolved)																	
Zinc (bioavailable)	4.38	4.18	4.4	1.99	4.0	4.0	4.0	4.0	4.1	4.07	4.09	4.1	4.1	1.07	2.1	4.4	4.4
Organics																	
Total petroleum hydrocarbons																	
Anthracene	0.0230	0.010	0.023	0.010	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.022	0.010	0.014	0.023	0.023
Benzo(a)pyrene	0.0210	0.00002	0.02	0.00002	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.019	0.00002	0.006	0.021	0.021
Benzo(b)fluoranthene																	
Benzo(k)fluoranthene																	
Benzo(g,h,i)-perylene																	
Fluoranthene	0.0200	0.001	0.02	0.0006	0.017	0.017	0.017	0.017	0.018	0.018	0.018	0.018	0.02	0.0006	0.0	0.020	0.0
Naphthalene																	
Phenol	2.2	0.13	2.18	0.87	2.01	2.01	2.01	2.01	2.03	2.03	2.04	2.04	2.06	0.77	1.2	2.183	2.2
Anionic Polyelectrolyte	1000.0	0.00	991.60	0.00	856.00	856.00	859.91	859.91	872.22	872.22	879.51	879.51	892.73	0.00	302.1	991.597	999.3

	Difference of upstream quality and PEC (ug/l) B1	C1	D1	E2	D2	E1	A3	A1+SC1	Test 3 - Is difference between u/s conc and PEC > 10% of AA EQS? B1	C1	D1	E2	D2	E1	A3	A1+SC1
Inorganics																
Chloride																
Sulphate																
Ammoniacal nitrogen	-44.6	-64.2	-0.29	-0.92	-0.55	-0.99	19.64	-0.35	N	N	N	N	N	N	N	N
Phosphate (orthophosphate as	75.36	49.65	0.23	0.71	0.42	0.77	16.62	0.588	Y	Y	N	N	N	N	Y	N
Nitrate (as NO3)	1770.99	6895.94	31.47	99.16	58.79	106.43	1665.86	13.828	N	Y	N	N	N	N	N	N
Metals																
Antimony																
Arsenic																
Boron																
Cadmium	0.49	0.39	0.002	0.006	0.003	0.006	0.15	0.0038	Y	Y	N	N	N	N	Y	N
Cobalt	0.69	0.60	0.00	0.01	0.01	0.01	0.25	0.0054	Y	Y	N	N	N	N	N	N
Copper (dissolved)																
Copper (bioavailable)	0.30	0.25	0.001	0.004	0.002	0.00	0.08	0.0023	Y	Y	N	N	N	N	N	N
Chromium (III)	0.49	0.64	0.00	0.01	0.01	0.01	0.24	0.0038	Y	Y	N	N	N	N	N	N
Iron	282.6	-406.6	-1.86	-5.85	-3.47	-6.28	64.95	2.207	Y	N	N	N	N	N	N	N
Lead (dissolved)																
Lead (bioavailable)	1.42	1.22	0.01	0.02	0.01	0.02	0.43	0.011	Y	Y	N	N	N	N	Y	N
Manganese (dissolved)																
Manganese (bioavailable)	-24.54	-39.50	-0.18	-0.57	-0.34	-0.61	-9.62	-0.192	N	N	N	N	N	N	N	N
Mercury																
Molybdenum																
Nickel (dissolved)																
Nickel (bioavailable)																
Selenium (dissolved)	0.24	0.26	0.001	0.004	0.002	0.00	0.03	0.002	Y	Y	N	N	N	N	N	N
Vanadium																
Zinc (dissolved)																
Zinc (bioavailable)	0.20	2.05	0.009	0.029	0.017	0.03	1.00	0.002	N	Y	N	N	N	N	N	N
Organics																
Total petroleum hydrocarbons																
Anthracene	0.01	0.01	0.000	0.000	0.000	0.00	0.0039	0.00010	Y	Y	N	N	N	N	N	N
Benzo(a)pyrene	0.02	0.02	0.0001	0.0003	0.0002	0.00	0.0063	0.00016	Y	Y	Y	Y	Y	Y	Y	Y
Benzo(b)fluoranthene																
Benzo(k)fluoranthene																
Benzo(g,h,i)-perylene																
Fluoranthene	0.02	0.02	0.0001	0.0002	0.0001	0.00	0.01	0.00015	Y	Y	N	N	N	N	Y	N
Naphthalene																
Phenol	2.05	1.14	0.0052	0.0164	0.0097	0.02	0.43	0.01600	Y	Y	N	N	N	N	N	N
Anionic Polyelectrolyte	991.60	856.00	3.9070	12.3094	7.2974	13.21	302.11	7.74267	Y	Y	N	N	N	N	N	N

(green shading)	Shaded cells take 10% of EQS as no upstream data are available
(grey shading)	Shaded cells are consecutively downstream of each other in the same receiving watercourse

Appendix D - Table 3b - Part A Test 3 Calculation of Freshwater Predicted Environmental Concentration for MAC

	Predicted discharge conc (ug/l)	Tre'r Gof-Upstream Afon Cafnan				Afon Cafnan		Afon Cafnan		Afon Cafnan		Afon Cafnan-Downstream		Nant Cemaes		Tre'r Gof outflow	
		Upstream conc (ug/l)	PEC (ug/l)	Upstream conc (ug/l)	PEC (ug/l)	Upstream conc (ug/l)	PEC (ug/l)	Upstream conc (ug/l)	PEC (ug/l)	Upstream conc (ug/l)	PEC (ug/l)	Upstream conc (ug/l)	PEC (ug/l)	Upstream conc (ug/l)	PEC (ug/l)	Upstream conc (ug/l)	PEC (ug/l)
		B1		C1		D1		E2		D2		E1		A3		A1+SC1	
Inorganics																	
Chloride	4780																
Sulphate	17620																
Ammoniacal nitrogen	175																
Phosphate (orthophosphate as P	138																
Nitrate (as NO3)	15036																
Metals																	
Antimony	7.5																
Arsenic	1.7																
Boron	24.8																
Cadmium	0.6	0.10	0.59	0.13	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.10	0.59	0.59	0.59
Cobalt	1.0																
Copper (dissolved)	9.3																
Copper (bioavailable)	0.4																
Chromium (III)	2.0																
Iron	395.0																
Lead (dissolved)	13.0	1.39	13.0	1.39	13.0	13.0	13.0	13.0	13.0	13.00	13.0	13.00	13.0	1.27	12.9	13.00	13.0
Lead (bioavailable)	1.4																
Manganese (dissolved)																	
Manganese (bioavailable)	20.0																
Mercury	0.1	0.010	0.09	0.01	0.09	0.09	0.09	0.09	0.09	0.09	0.1	0.09	0.1	0.01	0.09	0.09	0.09
Molybdenum	1.5																
Nickel (dissolved)	1.6																
Nickel (bioavailable)	0.3																
Selenium (dissolved)	1.0																
Vanadium	1.2																
Zinc (dissolved)	14.1																
Zinc (bioavailable)	4.4																
Organics																	
Total petroleum hydrocarbons	13.7																
Anthracene	0.023	0.01	0.023	0.01	0.02	0.023	0.02	0.023	0.02	0.023	0.023	0.02	0.023	0.010	0.023	0.02	0.023
Benzo(a)pyrene	0.021																
Benzo(b)fluoranthene	0.021	0.0017	0.021	0.0017	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.02	0.021	0.002	0.021	0.02	0.021
Benzo(k)fluoranthene	0.020	0.0017	0.020	0.0017	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.02	0.020	0.002	0.020	0.02	0.020
Benzo(g,h,i)-perylene	0.028	0.0008	0.028	0.0008	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.03	0.028	0.001	0.028	0.03	0.028
Fluoranthene	0.020	0.0006	0.020	0.0006	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.02	0.020	0.001	0.020	0.02	0.020
Naphthalene	0.082																
Phenol	2.2																
Anionic Polyelectrolyte	1000.0																

	Difference of upstream quality and PEC (ug/l)								Test 3 - Is difference between u/s conc and PEC > 10% of MAC EQS?							
	B1	C1	D1	E2	D2	E1	A3	A1+SC1	B1	C1	D1	E2	D2	E1	A3	SC1
Inorganics																
Chloride																
Sulphate																
Ammoniacal nitrogen																
Phosphate (orthophosphate as P																
Nitrate (as NO3)																
Metals																
Antimony																
Arsenic																
Boron																
Cadmium	0.49	0.46	0.00	0.00	0.00	0.00	0.49	0.0000	Y	Y	N	N	N	N	Y	N
Cobalt																
Copper (dissolved)																
Copper (bioavailable)																
Chromium (III)																
Iron																
Lead (dissolved)	11.61	11.60	0.00	0.00	0.00	0.00	11.62	0.0008	Y	Y	N	N	N	N	Y	N
Lead (bioavailable)																
Manganese (dissolved)																
Manganese (bioavailable)																
Mercury	0.08	0.08	0.00	0.00	0.00	0.00	0.08	0.0000	Y	Y	N	N	N	N	Y	N
Molybdenum																
Nickel (dissolved)																
Nickel (bioavailable)																
Selenium (dissolved)																
Vanadium																
Zinc (dissolved)																
Zinc (bioavailable)																
Organics																
Total petroleum hydrocarbons																
Anthracene	0.013	0.013	0.000	0.000	0.000	0.000	0.013	0.000	Y	Y	N	N	N	N	Y	N
Benzo(a)pyrene																
Benzo(b)fluoranthene	0.019	0.019	0.000	0.000	0.000	0.000	0.019	0.0000	Y	Y	N	N	N	N	Y	N
Benzo(k)fluoranthene	0.018	0.018	0.000	0.000	0.000	0.000	0.018	0.0000	Y	Y	N	N	N	N	Y	N
Benzo(g,h,i)-perylene	0.027	0.027	0.000	0.000	0.000	0.000	0.027	0.0000	Y	Y	N	N	N	N	Y	N
Fluoranthene	0.019	0.019	0.000	0.000	0.000	0.000	0.019	0.0000	Y	Y	N	N	N	N	Y	N
Naphthalene																
Phenol																
Anionic Polyelectrolyte																

(green shading)	Shaded cells take 10% of EQS as no upstream data are available
(grey shading)	Shaded cells are consecutively downstream of each other in the same receiving watercourse

Appendix D - Table 4 - Part A Test 4 Comparison of Predicted Environmental Concentration to EQS

	Test 4 - Is PEC > AA EQS?								Test 4 - Is PEC > MAC EQS?							
	B1	C1	D1	E2	D2	E1	A3	A1+ SC1	B1	C1	D1	E2	D2	E1	A3	A1+ SC1
Inorganics																
Chloride																
Sulphate																
Ammoniacal nitrogen	N	N	N	N	N	N	N	N								
Phosphate (orthophosphate as P)	Y	Y	Y	Y	Y	Y	Y	Y								
Nitrate (as NO3)	N	N	N	N	N	N	N	N								
Metals																
Antimony																
Arsenic																
Boron																
Cadmium	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N
Cobalt	N	N	N	N	N	N	N	N								
Copper (dissolved)																
Copper (bioavailable)	N	N	N	N	N	N	N	N								
Chromium (III)	N	N	N	N	N	N	N	N								
Iron	N	N	N	N	N	N	N	N								
Lead (dissolved)									N	N	N	N	N	N	N	N
Lead (bioavailabe)	Y	Y	Y	Y	Y	Y	N	Y								
Manganese (dissolved)																
Manganese (bioavailable)	N	N	N	N	N	N	N	N								
Mercury									Y	Y	Y	Y	Y	Y	Y	Y
Molybdenum																
Nickel (dissolved)																
Nickel (bioavailable)																
Selenium (dissolved)	N	N	N	N	N	N	N	N								
Vanadium																
Zinc (dissolved)																
Zinc (bioavailable)	N	N	N	N	N	N	N	N								
Organics																
Total petroleum hydrocarbons																
Anthracene	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Benzo(a)pyrene	Y	Y	Y	Y	Y	Y	Y	Y								
Benzo(b)fluoranthene									Y	Y	Y	Y	Y	Y	Y	Y
Benzo(k)fluoranthene									Y	Y	Y	Y	Y	Y	Y	Y
Benzo(g,h,i)-perylene									Y	Y	Y	Y	Y	Y	Y	Y
Fluoranthene	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N
Naphthalene																
Phenol	N	N	N	N	N	N	N	N								
Anionic Polyelectrolyte	N	N	N	N	N	N	N	N								

Appendix D - Table 5 - Part A Test 1 Screening against EQSs for Groundwater Discharges to the Marine Environment

	Concentration used for long term assessment	Concentration used for short term assessment			Marine Test 1	
	Mean Discharge	Mean Discharge	Marine EQS (ug/l)		Is discharge conc >	Is discharge conc >
Substance	**Concentration (ug/l)**	**Concentration (ug/l)**	**AA EQS**	**MAC EQS**	**100% of AA EQS?**	**100% of MAC EQS?**
Inorganics						
Sulphate	30348	30348	-	-		
Cyanide (total)	6.30	6.30	1	5	Y	Y
Metals						
Arsenic	1.00	1.00	25	-	N	
Boron	30.96	31	7000	-	N	
Cadmium	0.05	0.05	0.2	-	N	
Copper (dissolved)	1.32	1.32	3.76	-	N	
Chromium (VI)	52.17	52.17	0.6	32	Y	Y
Chromium (III)	1.48	1.48	-	-		
Iron	36.13	36.13	1000	-	N	
Lead (dissolved)	1.00	1.00	1.3	14	N	N
Manganese (dissolved)	102.00	102	-	-		
Mercury	0.050	0.050	-	0.07		N
Nickel (dissolved)	16.52	16.52	8.6	34	Y	N
Selenium (dissolved)	1.00	1.00	2	-	N	
Vanadium	1.00	1.00	100	-	N	
Zinc (dissolved)	37.76	37.76	7.9	-	Y	
Organics						
Total petroleum hydrocarbons	50.00	50.00	250	-	N	
Anthracene	0.61	0.61	0.1	0.1	Y	Y
Benzo(a)pyrene	0.61	0.61	0.00017	0.027	Y	Y
Benzo(b)fluoranthene	0.61	0.61	-	0.017		Y
Benzo(k)fluoranthene	0.61	0.61	-	0.017		Y
Benzo(g,h,i)-perylene	0.61	0.61	-	0.00082		Y
Fluoranthene	0.61	0.61	0.0063	0.12	Y	Y
Naphthalene	0.64	0.64	2	130	N	N
Phenol	1.160	1.160	7.7	46	N	N
Anionic Polyelectrolyte	1000	1000	7500		N	

Shaded cells are below the limit of detection in all samples.

Appendix E - H1 Assessment – Further Tests for Marine Discharges

Appendix E – Further tests for marine discharges

Test 2 – Check whether the discharge is to the low water channel in an estuary

Test 3 - Check whether the discharge is to a location with restricted dilution or dispersion

Test 4 - Check whether the discharge point is located less than 50m offshore from chart datum, or is located less than 1m below chart datum

Test 5 – Check if the effective volume flux of the discharge is within allowable limits

Although the majority of discharges are not direct to Marine waters (only the discharge from A2 and PA/PB/PC are considered as discharges direct to coastal waters), the assessment of discharges to freshwater show that the discharge is not diluted greatly and given the relatively short distance to the coast for most of the other discharges, concentrations at the coast would not be much lower than the discharge concentration at the point of discharge following mixing. As such, assessment of secondary effects on marine waters from those substances in freshwater outflows “failing” Test 1 for marine waters is warranted.

The further tests for marine waters for those substances failing Test 1 relate to the location of the discharge and whether there is likely to be mixing and dilution of the substances in the coastal water. For the discharges considered here (A2 and PA/PB/PC), the discharge locations are both new direct to sea discharge points and so there will be no freshwater channel. Test 2 therefore does not apply.

Test 3 for marine waters relates to assessing whether the discharge is to a zone with high or low natural dispersion. In this case the discharges are not believed to be to areas with restricted dilution or dispersion and it is not considered to be of relevance. Test 4 considers the location of the discharge and states that if the discharge does contain substances at concentrations above EQS and if the discharge location is less than 50m offshore from where the sea-bed is at Chart Datum (CD) or the sea-bed at the discharge location is less than 1m below CD, then Phase 2: Modelling should be undertaken to ascertain in detail the area of impact above EQS.

Test 5 for marine waters considers the Effective Volume Flux of the discharge. This test is not required for the assessed discharges as both are indicated for modelling assessment at Test 4.

The assessment of the further tests for marine waters does indicate that further modelling of the discharges should be undertaken.

Appendix F - H1 Assessment – Calculation of Substance Loads

Appendix F Table 1 - Part B Calculation of Substance Loads

Substance	Annual Significant Load (kg/yr)	Calculation of Significant Load for each Discharge Point (kg/yr)										Groundwater	**Site Total (kg/yr)**	Comments
		B1	C1	D1	E2	D2	E1	A3	A1	A2	PA/PB/PC	PA/PB/PC		
Anthracene	1	0.0030	0.0018	0.0004	0.0012	0.0008	0.0016	0.0008	0.0044	0.0006	0.0037	0.0267	**0.0450**	
Brominated diphenyl ether	1													Not tested in leaching or soil tests but unlikley to be present
Cadmium	5	0.0762	0.0461	0.0090	0.0317	0.0198	0.0411	0.0215	0.1127	0.0164	0.0941	0.0022	**0.4708**	
C10-13 Chloroalkanes	1													Not tested in leaching or soil tests but unlikley to be present
Endosulphan	1													Not tested in leaching or soil tests but unlikley to be present
Hexachlorobenzene	1													Not detected in soils or leaching tests conducted during DOnGI
Hexachlorobutadiene	1													Not detected in soils or leaching tests conducted during DOnGI
Hexachloro-cyclohexane	1													Not tested in leaching or soil tests but unlikley to be present
Mercury and its compounds	1	0.0116	0.0070	0.0014	0.0048	0.0030	0.0063	0.0033	0.0172	0.0025	0.0144	0.0022	**0.0737**	
Nonylphenol (4-Nonylphenol)	1													Not tested in leaching or soil tests but unlikley to be present
Pentachlorobenzene	1													Not tested in leaching or soil tests but unlikley to be present
Polycyclic aromatic hydrocarbons (PAHs)*	5	0.014	0.009	0.002	0.006	0.004	0.008	0.0041	0.0214	0.0031	0.0179	0.1335	**0.2225**	
Tributyltin compounds	1													Not tested in leaching or soil tests but unlikley to be present

* The sum of the annual load calculated for the individual PAH Benzo(a)-pyrene and the annual loads calculated from the combined determinands Benzo(b)-fluor-anthene + Benzo(k)fluor-anthene and Benzo(g,h,i)-perylene + Indeno(1,2,3-cd)-pyrene.

Annual loads are calculated by multiplying the average discharge concentration by the average discharge flow rate

Appendix G - Freshwater Modelling Results

Appendix G – Freshwater modelling results

RQP forward model runs

UNITS

All flows: m^3/d

All concentrations: μg/l

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 13.58

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Orthophosphate (P)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	62.00
Standard deviation of quality	120.00
90-percentile	140.83

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	133.00
Standard deviation of quality	395.98
... or 95-percentile	510.04

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	124.63
Standard deviation of quality	249.47
90-percentile quality	280.06
95-percentile quality	482.79
99-percentile quality	1184.8

DISCHARGE QUALITY

Mean quality	132.60
Standard deviation of quality	276.07
95-percentile quality	526.41
99-percentile quality	1354.1
99.5-percentile quality	1749.1

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 14.03

ENVIRONMENT AGENCY

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Copper (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	0.05
Standard deviation of quality	0.01
90-percentile	0.06

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	0.25
Standard deviation of quality	0.19
... or 95-percentile	0.60

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	0.23
Standard deviation of quality	0.16
90-percentile quality	0.43
95-percentile quality	0.56
99-percentile quality	0.81

DISCHARGE QUALITY

Mean quality	0.26
Standard deviation of quality	0.18
95-percentile quality	0.61
99-percentile quality	0.92
99.5-percentile quality	1.03

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 14.05

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Iron (dissolved)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	110.00
Standard deviation of quality	280.00
90-percentile	247.66

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	394.00
Standard deviation of quality	294.00
... or 95-percentile	943.32

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	366.91
Standard deviation of quality	259.09
90-percentile quality	682.81
95-percentile quality	882.46
99-percentile quality	1289.9

DISCHARGE QUALITY

Mean quality	404.27
Standard deviation of quality	285.78
95-percentile quality	956.52
99-percentile quality	1449.2
99.5-percentile quality	1621.9

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 14.07

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Lead (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	0.01
Standard deviation of quality	0.01
90-percentile	0.02

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	0.67
Standard deviation of quality	1.23
... or 95-percentile	2.36

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	0.60
Standard deviation of quality	0.93
90-percentile quality	1.40
95-percentile quality	2.25
99-percentile quality	4.50

DISCHARGE QUALITY

Mean quality	0.68
Standard deviation of quality	1.03
95-percentile quality	2.42
99-percentile quality	5.16
99.5-percentile quality	6.33

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 14.08

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Lead (dissolved)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	1.39
Standard deviation of quality	0.88
90-percentile	2.47

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	6.45
Standard deviation of quality	11.01
... or 95-percentile	22.27

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	5.97
Standard deviation of quality	8.47
90-percentile quality	13.42
95-percentile quality	21.23
99-percentile quality	41.35

DISCHARGE QUALITY

Mean quality	6.60
Standard deviation of quality	9.42
95-percentile quality	22.82
99-percentile quality	47.33
99.5-percentile quality	57.67

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 14.09

ENVIRONMENT AGENCY

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Anionic Polyelectrolyte

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	0.00
Standard deviation of quality	0.00
90-percentile	

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	1000.0
Standard deviation of quality	0.00
... or 95-percentile	1000.0

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	870.14
Standard deviation of quality	112.45
90-percentile quality	972.76
95-percentile quality	981.15
99-percentile quality	989.32

DISCHARGE QUALITY

Mean quality	1000.0
Standard deviation of quality	0.25
95-percentile quality	1000.0
99-percentile quality	1000.0
99.5-percentile quality	1000.0

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 09/02/2018 at 14.36

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Chromium (iii)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	1.53
Standard deviation of quality	2.00
90-percentile	3.34

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	1.52
Standard deviation of quality	1.35
... or 95-percentile	3.98

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	1.56
Standard deviation of quality	1.19
90-percentile quality	3.00
95-percentile quality	3.89
99-percentile quality	5.99

DISCHARGE QUALITY

Mean quality	1.56
Standard deviation of quality	1.29
95-percentile quality	4.04
99-percentile quality	6.51
99.5-percentile quality	7.40

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 14.12

ENVIRONMENT AGENCY

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Orthophosphate (P)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	80.00
Standard deviation of quality	200.00
90-percentile	180.38

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	133.00
Standard deviation of quality	395.98
... or 95-percentile	510.04

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	107.30
Standard deviation of quality	171.51
90-percentile quality	251.25
95-percentile quality	382.24
99-percentile quality	816.48

DISCHARGE QUALITY

Mean quality	132.60
Standard deviation of quality	276.07
95-percentile quality	526.41
99-percentile quality	1354.1
99.5-percentile quality	1749.1

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 14.15

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Copper (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	0.06
Standard deviation of quality	0.03
90-percentile	0.10

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	0.25
Standard deviation of quality	0.19
... or 95-percentile	0.60

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	0.16
Standard deviation of quality	0.10
90-percentile quality	0.28
95-percentile quality	0.36
99-percentile quality	0.53

DISCHARGE QUALITY

Mean quality	0.26
Standard deviation of quality	0.18
95-percentile quality	0.61
99-percentile quality	0.92
99.5-percentile quality	1.03

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 14.16

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Lead (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	0.01
Standard deviation of quality	0.01
90-percentile	0.02

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	0.67
Standard deviation of quality	1.23
... or 95-percentile	2.36

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	0.35
Standard deviation of quality	0.56
90-percentile quality	0.80
95-percentile quality	1.31
99-percentile quality	2.76

DISCHARGE QUALITY

Mean quality	0.68
Standard deviation of quality	1.03
95-percentile quality	2.42
99-percentile quality	5.16
99.5-percentile quality	6.33

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 14.18

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Lead (dissolved)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	1.39
Standard deviation of quality	1.32
90-percentile	2.82

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	6.45
Standard deviation of quality	11.01
... or 95-percentile	22.27

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	4.03
Standard deviation of quality	5.15
90-percentile quality	8.32
95-percentile quality	13.20
99-percentile quality	26.37

DISCHARGE QUALITY

Mean quality	6.60
Standard deviation of quality	9.42
95-percentile quality	22.82
99-percentile quality	47.33
99.5-percentile quality	57.67

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 13/02/2018 at 11.01

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Nitrate (NO3)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	6980.0
Standard deviation of quality	5330.0
90-percentile	13221.7

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	15006.0
Standard deviation of quality	30555.9
... or 95-percentile	54309.9

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	11240.8
Standard deviation of quality	13594.7
90-percentile quality	21768.5
95-percentile quality	34230.7
99-percentile quality	71566.9

DISCHARGE QUALITY

Mean quality	15264.9
Standard deviation of quality	24796.4
95-percentile quality	55781.3
99-percentile quality	124057.4
99.5-percentile quality	154058.2

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 12/12/2017 at 14.22

ENVIRONMENT AGENCY

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Anionic Polyelectrolyte

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	0.00
Standard deviation of quality	0.00
90-percentile	

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	1000.0
Standard deviation of quality	0.00
... or 95-percentile	1000.0

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	497.41
Standard deviation of quality	168.69
90-percentile quality	721.54
95-percentile quality	770.43
99-percentile quality	837.99

DISCHARGE QUALITY

Mean quality	1000.0
Standard deviation of quality	0.25
95-percentile quality	1000.0
99-percentile quality	1000.0
99.5-percentile quality	1000.0

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 09/02/2018 at 14.42

ENVIRONMENT AGENCY

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Chromium (iii)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	1.27
Standard deviation of quality	1.80
90-percentile	2.81

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	1.52
Standard deviation of quality	1.35
... or 95-percentile	3.98

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	1.42
Standard deviation of quality	1.10
90-percentile quality	2.70
95-percentile quality	3.54
99-percentile quality	5.56

DISCHARGE QUALITY

Mean quality	1.56
Standard deviation of quality	1.29
95-percentile quality	4.04
99-percentile quality	6.51
99.5-percentile quality	7.40

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 09/02/2018 at 17.10

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Zinc (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	1.99
Standard deviation of quality	3.63
90-percentile	4.51

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	3.56
Standard deviation of quality	5.42
... or 95-percentile	11.84

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	2.84
Standard deviation of quality	3.05
90-percentile quality	5.99
95-percentile quality	8.66
99-percentile quality	15.00

DISCHARGE QUALITY

Mean quality	3.65
Standard deviation of quality	4.78
95-percentile quality	12.11
99-percentile quality	24.00
99.5-percentile quality	28.89

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 14.24

Name of discharge	A3
Name of river	Nant Cemaes
Name of determinand	Orthophosphate (P)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	2344.0
95% exceedence flow	231.00
Mean quality	80.00
Standard deviation of quality	40.00
90-percentile	131.07

DISCHARGE DATA

Mean flow	100.00
Standard deviation of flow	107.00
Mean quality	133.00
Standard deviation of quality	395.98
... or 95-percentile	510.04

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	84.01
Standard deviation of quality	43.55
90-percentile quality	135.11
95-percentile quality	164.41
99-percentile quality	233.45

DISCHARGE QUALITY

Mean quality	132.60
Standard deviation of quality	276.07
95-percentile quality	526.41
99-percentile quality	1354.1
99.5-percentile quality	1749.1

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 14.26

Name of discharge	A3
Name of river	Nant Cemaes
Name of determinand	Lead (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	2344.0
95% exceedence flow	231.00
Mean quality	0.02
Standard deviation of quality	0.01
90-percentile	0.03

DISCHARGE DATA

Mean flow	100.00
Standard deviation of flow	107.00
Mean quality	0.67
Standard deviation of quality	1.23
... or 95-percentile	2.36

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	0.07
Standard deviation of quality	0.09
90-percentile quality	0.13
95-percentile quality	0.20
99-percentile quality	0.46

DISCHARGE QUALITY

Mean quality	0.68
Standard deviation of quality	1.03
95-percentile quality	2.42
99-percentile quality	5.16
99.5-percentile quality	6.33

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 14.27

Name of discharge	A3
Name of river	Nant Cemaes
Name of determinand	Lead (dissolved)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	2344.0
95% exceedence flow	231.00
Mean quality	1.27
Standard deviation of quality	0.95
90-percentile	2.39

DISCHARGE DATA

Mean flow	100.00
Standard deviation of flow	107.00
Mean quality	6.45
Standard deviation of quality	11.01
... or 95-percentile	22.27

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	1.64
Standard deviation of quality	1.20
90-percentile quality	2.98
95-percentile quality	3.86
99-percentile quality	6.08

DISCHARGE QUALITY

Mean quality	6.60
Standard deviation of quality	9.42
95-percentile quality	22.82
99-percentile quality	47.33
99.5-percentile quality	57.67

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 14.28

Name of discharge	A3
Name of river	Nant Cemaes
Name of determinand	Anionic Polyelectrolyte

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	2344.0
95% exceedence flow	231.00
Mean quality	0.00
Standard deviation of quality	0.00
90-percentile	

DISCHARGE DATA

Mean flow	100.00
Standard deviation of flow	107.00
Mean quality	1000.0
Standard deviation of quality	0.00
... or 95-percentile	1000.0

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	66.80
Standard deviation of quality	56.20
90-percentile quality	137.87
95-percentile quality	179.84
99-percentile quality	269.26

DISCHARGE QUALITY

Mean quality	1000.0
Standard deviation of quality	0.25
95-percentile quality	1000.0
99-percentile quality	1000.0
99.5-percentile quality	1000.0

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 14.30

Name of discharge	A1
Name of river	Trer Gof
Name of determinand	Orthophosphate (P)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	747.00
95% exceedence flow	45.00
Mean quality	62.00
Standard deviation of quality	120.00
90-percentile	140.83

DISCHARGE DATA

Mean flow	523.00
Standard deviation of flow	321.00
Mean quality	133.00
Standard deviation of quality	395.98
... or 95-percentile	510.04

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	103.33
Standard deviation of quality	182.58
90-percentile quality	232.56
95-percentile quality	382.45
99-percentile quality	802.07

DISCHARGE QUALITY

Mean quality	132.60
Standard deviation of quality	276.07
95-percentile quality	526.41
99-percentile quality	1354.1
99.5-percentile quality	1749.1

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 14.34

Name of discharge	A1
Name of river	Trer Gof
Name of determinand	Anionic Polyelectrolyte

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	747.00
95% exceedence flow	45.00
Mean quality	0.00
Standard deviation of quality	0.00
90-percentile	

DISCHARGE DATA

Mean flow	523.00
Standard deviation of flow	321.00
Mean quality	1000.0
Standard deviation of quality	0.00
... or 95-percentile	1000.0

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	556.47
Standard deviation of quality	207.60
90-percentile quality	831.73
95-percentile quality	873.78
99-percentile quality	926.83

DISCHARGE QUALITY

Mean quality	1000.0
Standard deviation of quality	0.25
95-percentile quality	1000.0
99-percentile quality	1000.0
99.5-percentile quality	1000.0

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 09/02/2018 at 14.46

Name of discharge	A1
Name of river	Trer Gof
Name of determinand	Lead (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	747.00
95% exceedence flow	45.00
Mean quality	0.01
Standard deviation of quality	0.01
90-percentile	0.02

DISCHARGE DATA

Mean flow	523.00
Standard deviation of flow	321.00
Mean quality	0.67
Standard deviation of quality	1.23
... or 95-percentile	2.36

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	0.39
Standard deviation of quality	0.66
90-percentile quality	0.92
95-percentile quality	1.48
99-percentile quality	3.07

DISCHARGE QUALITY

Mean quality	0.68
Standard deviation of quality	1.03
95-percentile quality	2.42
99-percentile quality	5.16
99.5-percentile quality	6.33

Appendix G – Freshwater modelling results

RQP backward model runs

UNITS

All flows: m^3/d

All concentrations: μg/l

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 14.53

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Orthophosphate (P)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	62.00
Standard deviation of quality	120.00
90-percentile	140.83

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	133.00
Standard deviation of quality	395.98
... or 95-percentile	510.04

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	78.00

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	78.00
Standard deviation of quality	150.21
90-percentile quality	171.43
95-percentile quality	290.10
99-percentile quality	712.36
Quality target (Mean)	78.00

DISCHARGE QUALITY NEEDED

Mean quality	79.65
Standard deviation of quality	165.83
95-percentile quality	316.20
99-percentile quality	813.34
99.5-percentile quality	1050.6

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 31/01/2018 at 15.02

ENVIRONMENT AGENCY

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Copper (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	0.05
Standard deviation of quality	0.01
90-percentile	0.06

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	0.25
Standard deviation of quality	0.19
... or 95-percentile	0.60

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	1.00

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	1.00
Standard deviation of quality	0.73
90-percentile quality	1.91
95-percentile quality	2.47
99-percentile quality	3.56
Quality target (Mean)	1.00

DISCHARGE QUALITY NEEDED

Mean quality	1.14
Standard deviation of quality	0.81
95-percentile quality	2.70
99-percentile quality	4.09
99.5-percentile quality	4.58

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 15.04

Environment Agency

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Iron (dissolved)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	110.00
Standard deviation of quality	280.00
90-percentile	247.66

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	394.00
Standard deviation of quality	294.00
... or 95-percentile	943.32

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	1000.0

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	1000.0
Standard deviation of quality	722.45
90-percentile quality	1889.5
95-percentile quality	2447.8
99-percentile quality	3514.5
Quality target (Mean)	1000.0

DISCHARGE QUALITY NEEDED

Mean quality	1129.0
Standard deviation of quality	798.10
95-percentile quality	2671.3
99-percentile quality	4047.3
99.5-percentile quality	4529.6

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 15.07

Environment Agency

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Lead (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	0.01
Standard deviation of quality	0.01
90-percentile	0.02

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	0.67
Standard deviation of quality	1.23
... or 95-percentile	2.36

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	1.20

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	1.20
Standard deviation of quality	1.85
90-percentile quality	2.78
95-percentile quality	4.48
99-percentile quality	8.98
Quality target (Mean)	1.20

DISCHARGE QUALITY NEEDED

Mean quality	1.37
Standard deviation of quality	2.05
95-percentile quality	4.83
99-percentile quality	10.30
99.5-percentile quality	12.64

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 31/01/2018 at 15.08

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Lead (dissolved)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	1.39
Standard deviation of quality	0.88
90-percentile	2.47

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	6.45
Standard deviation of quality	11.01
... or 95-percentile	22.27

DOWNSTREAM RIVER QUALITY TARGET

Quality target	14.00
Percentile	95.00

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	4.00
Standard deviation of quality	5.58
90-percentile quality	8.87
95-percentile quality	14.00
99-percentile quality	27.29
Quality target (95-percentile)	14.00

DISCHARGE QUALITY NEEDED

Mean quality	4.35
Standard deviation of quality	6.21
95-percentile quality	15.04
99-percentile quality	31.19
99.5-percentile quality	38.01

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 31/01/2018 at 15.12

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Anionic Polyelectrolyte

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	0.00
Standard deviation of quality	0.00
90-percentile	

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	1000.0
Standard deviation of quality	0.00
... or 95-percentile	1000.0

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	7500.0

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	7500.0
Standard deviation of quality	969.25
90-percentile quality	8384.5
95-percentile quality	8456.8
99-percentile quality	8527.3
Quality target (Mean)	7500.0

DISCHARGE QUALITY NEEDED

Mean quality	8619.4
Standard deviation of quality	0.00
95-percentile quality	8619.3
99-percentile quality	8619.3
99.5-percentile quality	8619.3

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 09/02/2018 at 15.00

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Chromium (iii)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	1.53
Standard deviation of quality	2.00
90-percentile	3.34

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	1.52
Standard deviation of quality	1.35
... or 95-percentile	3.98

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	4.70

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	4.70
Standard deviation of quality	3.84
90-percentile quality	9.17
95-percentile quality	12.62
99-percentile quality	18.97
Quality target (Mean)	4.70

DISCHARGE QUALITY NEEDED

Mean quality	5.15
Standard deviation of quality	4.26
95-percentile quality	13.33
99-percentile quality	21.45
99.5-percentile quality	24.40

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 31/01/2018 at 15.18

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Orthophosphate (P)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	80.00
Standard deviation of quality	200.00
90-percentile	180.38

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	133.00
Standard deviation of quality	369.02
... or 95-percentile	506.76

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	78.00

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	78.00
Standard deviation of quality	118.05
90-percentile quality	183.05
95-percentile quality	276.47
99-percentile quality	576.62
Quality target (Mean)	78.00

DISCHARGE QUALITY NEEDED

Mean quality	74.93
Standard deviation of quality	149.43
95-percentile quality	293.96
99-percentile quality	736.49
99.5-percentile quality	944.61

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 31/01/2018 at 15.21

ENVIRONMENT AGENCY

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Copper (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	0.06
Standard deviation of quality	0.03
90-percentile	0.10

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	0.25
Standard deviation of quality	0.19
... or 95-percentile	0.60

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	1.00

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	1.00
Standard deviation of quality	0.80
90-percentile quality	1.96
95-percentile quality	2.57
99-percentile quality	3.90
Quality target (Mean)	1.00

DISCHARGE QUALITY NEEDED

Mean quality	1.93
Standard deviation of quality	1.37
95-percentile quality	4.58
99-percentile quality	6.95
99.5-percentile quality	7.79

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 31/01/2018 at 15.22

ENVIRONMENT AGENCY

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Lead (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	0.01
Standard deviation of quality	0.01
90-percentile	0.02

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	0.67
Standard deviation of quality	1.23
... or 95-percentile	2.36

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	1.20

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	1.20
Standard deviation of quality	1.94
90-percentile quality	2.75
95-percentile quality	4.51
99-percentile quality	9.52
Quality target (Mean)	1.20

DISCHARGE QUALITY NEEDED

Mean quality	2.36
Standard deviation of quality	3.55
95-percentile quality	8.36
99-percentile quality	17.82
99.5-percentile quality	21.88

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 15.24

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Lead (dissolved)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	1.39
Standard deviation of quality	1.32
90-percentile	2.82

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	6.45
Standard deviation of quality	11.01
... or 95-percentile	22.27

DOWNSTREAM RIVER QUALITY TARGET

Quality target	14.00
Percentile	95.00

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	4.25
Standard deviation of quality	5.48
90-percentile quality	8.75
95-percentile quality	14.00
99-percentile quality	28.02
Quality target (95-percentile)	14.00

DISCHARGE QUALITY NEEDED

Mean quality	7.03
Standard deviation of quality	10.04
95-percentile quality	24.31
99-percentile quality	50.42
99.5-percentile quality	61.44

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 13/02/2018 at 10.50

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Nitrate (NO3)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	6980.0
Standard deviation of quality	5330.0
90-percentile	13221.7

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	15006.0
Standard deviation of quality	30555.9
... or 95-percentile	54309.9

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	50000.0

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	50000.0
Standard deviation of quality	81065.2
90-percentile quality	109717.7
95-percentile quality	186345.3
99-percentile quality	402273.1
Quality target (Mean)	50000.0

DISCHARGE QUALITY NEEDED

Mean quality	91846.3
Standard deviation of quality	149195.9
95-percentile quality	335627.7
99-percentile quality	746434.1
99.5-percentile quality	926944.5

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 15.16

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Anionic Polyelectrolyte

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	0.00
Standard deviation of quality	0.00
90-percentile	

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	1000.0
Standard deviation of quality	0.00
... or 95-percentile	1000.0

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	7500.0

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	7500.0
Standard deviation of quality	2543.6
90-percentile quality	10879.4
95-percentile quality	11616.7
99-percentile quality	12635.3
Quality target (Mean)	7500.0

DISCHARGE QUALITY NEEDED

Mean quality	15078.1
Standard deviation of quality	33.33
95-percentile quality	15078.2
99-percentile quality	15078.2
99.5-percentile quality	15078.2

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 09/02/2018 at 14.56

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Chromium (iii)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	1.27
Standard deviation of quality	1.80
90-percentile	2.81

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	1.52
Standard deviation of quality	1.35
... or 95-percentile	3.98

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	4.70

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	4.70
Standard deviation of quality	3.84
90-percentile quality	9.14
95-percentile quality	12.24
99-percentile quality	18.49
Quality target (Mean)	4.70

DISCHARGE QUALITY NEEDED

Mean quality	8.08
Standard deviation of quality	6.69
95-percentile quality	20.93
99-percentile quality	33.67
99.5-percentile quality	38.30

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 09/02/2018 at 17.21

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Zinc (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	1.99
Standard deviation of quality	3.63
90-percentile	4.51

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	3.56
Standard deviation of quality	5.42
... or 95-percentile	11.84

DOWNSTREAM RIVER QUALITY TARGET

Quality target	13.90
Percentile	90.00

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	6.59
Standard deviation of quality	8.05
90-percentile quality	13.90
95-percentile quality	21.85
99-percentile quality	40.27
Quality target (90-percentile)	13.90

DISCHARGE QUALITY NEEDED

Mean quality	11.08
Standard deviation of quality	14.50
95-percentile quality	36.77
99-percentile quality	72.87
99.5-percentile quality	87.70

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 15.28

Name of discharge	A3
Name of river	Nant Cemaes
Name of determinand	Orthophosphate (P)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	2344.0
95% exceedence flow	231.00
Mean quality	80.00
Standard deviation of quality	40.00
90-percentile	131.07

DISCHARGE DATA

Mean flow	100.00
Standard deviation of flow	107.00
Mean quality	133.00
Standard deviation of quality	369.02
... or 95-percentile	506.76

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	78.00

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	78.00
Standard deviation of quality	38.15
90-percentile quality	124.87
95-percentile quality	150.54
99-percentile quality	209.73
Quality target (Mean)	78.00

DISCHARGE QUALITY NEEDED

Mean quality	43.63
Standard deviation of quality	87.01
95-percentile quality	171.17
99-percentile quality	428.86
99.5-percentile quality	550.05

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 31/01/2018 at 15.29

Name of discharge	A3
Name of river	Nant Cemaes
Name of determinand	Lead (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	2344.0
95% exceedence flow	231.00
Mean quality	0.02
Standard deviation of quality	0.01
90-percentile	0.03

DISCHARGE DATA

Mean flow	100.00
Standard deviation of flow	107.00
Mean quality	0.67
Standard deviation of quality	1.23
... or 95-percentile	2.36

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	1.20

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	1.20
Standard deviation of quality	2.31
90-percentile quality	2.92
95-percentile quality	4.63
99-percentile quality	11.36
Quality target (Mean)	1.20

DISCHARGE QUALITY NEEDED

Mean quality	17.46
Standard deviation of quality	26.25
95-percentile quality	61.78
99-percentile quality	131.69
99.5-percentile quality	161.66

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 15.31

Name of discharge	A3
Name of river	Nant Cemaes
Name of determinand	Lead (dissolved)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	2344.0
95% exceedence flow	231.00
Mean quality	1.27
Standard deviation of quality	0.95
90-percentile	2.39

DISCHARGE DATA

Mean flow	100.00
Standard deviation of flow	107.00
Mean quality	6.45
Standard deviation of quality	11.01
... or 95-percentile	22.27

DOWNSTREAM RIVER QUALITY TARGET

Quality target	14.00
Percentile	95.00

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	4.54
Standard deviation of quality	6.31
90-percentile quality	9.58
95-percentile quality	14.00
99-percentile quality	31.65
Quality target (95-percentile)	14.00

DISCHARGE QUALITY NEEDED

Mean quality	49.43
Standard deviation of quality	70.60
95-percentile quality	170.96
99-percentile quality	354.56
99.5-percentile quality	432.04

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 31/01/2018 at 15.33

ENVIRONMENT AGENCY

Name of discharge	A3
Name of river	Nant Cemaes
Name of determinand	Anionic Polyelectrolyte

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	2344.0
95% exceedence flow	231.00
Mean quality	0.00
Standard deviation of quality	0.00
90-percentile	

DISCHARGE DATA

Mean flow	100.00
Standard deviation of flow	107.00
Mean quality	1000.0
Standard deviation of quality	0.00
... or 95-percentile	1000.0

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	7500.0

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	7500.0
Standard deviation of quality	6309.5
90-percentile quality	15478.9
95-percentile quality	20191.3
99-percentile quality	30230.9
Quality target (Mean)	7500.0

DISCHARGE QUALITY NEEDED

Mean quality	112272.1
Standard deviation of quality	85.35
95-percentile quality	112272.9
99-percentile quality	112273.0
99.5-percentile quality	112273.0

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 14.51

ENVIRONMENT AGENCY

Name of discharge	A1
Name of river	Trer Gof
Name of determinand	Orthophosphate (P)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	747.00
95% exceedence flow	45.00
Mean quality	62.00
Standard deviation of quality	120.00
90-percentile	140.83

DISCHARGE DATA

Mean flow	523.00
Standard deviation of flow	321.00
Mean quality	133.00
Standard deviation of quality	369.02
... or 95-percentile	506.76

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	78.00

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	78.00
Standard deviation of quality	122.59
90-percentile quality	178.23
95-percentile quality	271.33
99-percentile quality	549.95
Quality target (Mean)	78.00

DISCHARGE QUALITY NEEDED

Mean quality	88.48
Standard deviation of quality	176.43
95-percentile quality	347.09
99-percentile quality	869.60
99.5-percentile quality	1115.3

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 14.47

ENVIRONMENT AGENCY

Name of discharge	A1
Name of river	Trer Gof
Name of determinand	Anionic Polyelectrolyte

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	747.00
95% exceedence flow	45.00
Mean quality	0.00
Standard deviation of quality	0.00
90-percentile	

DISCHARGE DATA

Mean flow	523.00
Standard deviation of flow	321.00
Mean quality	1000.0
Standard deviation of quality	0.00
... or 95-percentile	1000.0

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	7500.0

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	7500.0
Standard deviation of quality	2798.1
90-percentile quality	11210.0
95-percentile quality	11776.8
99-percentile quality	12491.8
Quality target (Mean)	7500.0

DISCHARGE QUALITY NEEDED

Mean quality	13478.0
Standard deviation of quality	0.00
95-percentile quality	13478.0
99-percentile quality	13478.0
99.5-percentile quality	13478.0

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 12/02/2018 at 13.37

ENVIRONMENT AGENCY

Name of discharge	A1
Name of river	Trer Gof
Name of determinand	Lead (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	747.00
95% exceedence flow	45.00
Mean quality	0.01
Standard deviation of quality	0.01
90-percentile	0.02

DISCHARGE DATA

Mean flow	523.00
Standard deviation of flow	321.00
Mean quality	0.67
Standard deviation of quality	1.23
... or 95-percentile	2.36

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	1.20

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	1.20
Standard deviation of quality	2.03
90-percentile quality	2.82
95-percentile quality	4.55
99-percentile quality	9.42
Quality target (Mean)	1.20

DISCHARGE QUALITY NEEDED

Mean quality	2.10
Standard deviation of quality	3.16
95-percentile quality	7.45
99-percentile quality	15.87
99.5-percentile quality	19.49