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Horizon Nuclear Power Ltd

Cae Gwyn SSSI Hydroecological Assessment

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Contents

About your report 4
1. Introduction 5
1.1 Scope and objectives 5
1.2 Sources of information 5
1.3 Monitoring and assessment..6
1.4 Uncertainty and data gaps..7
2. Baseline environmental setting 8
2.1 Site description 8
2.2 Ecological interest and management of Cae Gwyn SSSI 8
2.2.1 Interest features 8
2.2.2 Groundwater dependence of plant communities at Cae Gwyn SSSI 9
2.2.3 Management and damaging operations..13
2.2.4 Site condition 13
2.3 Geology and soils..13
2.3.1 Bedrock geology 13
2.3.2 Superficial deposits 14
2.3.3 Soils and peat 14
2.4 Hydrology 15
2.4.1 Surface water flow routing 15
2.4.2 Walkover surveys..15
2.4.3 Flow data 17
2.5 Hydrogeology..18
2.5.1 Groundwater monitoring 18
2.5.2 Groundwater levels and flow 18
2.5.3 Water levels in the peat and soils 19
2.6 Water balance and water levels..21
2.6.1 Southern Basin 21
2.6.2 Northern Basin 21
2.6.3 Primary Outflow Basin..21
2.6.4 Western Basin..21
2.7 Water quality..21
2.7.1 Field parameters 22
2.7.2 Ionic balance..23
2.7.3 Inorganic analyses 24
2.7.4 Nutrients 29
2.7.5 Organic analyses 29
3. Conceptual hydrological models 30
3.1 Southern Basin 30
3.2 Northern Basin 31
3.3 Primary Outflow Basin..32

3.4 Western Basin......33
4. Hydroecological supporting conditions and assessment of sensitivity to change......34
4.1 Southern Basin......34
4.2 Northern Basin......37
4.3 Primary Outflow Basin......39
4.4 Western Basin......41
5. Conclusions......43
6. References......44

FIGURES

Figure D8-6-1-1 Cae Gwyn SSSI Location
Figure D8-6-1-2 Cae Gwyn Location and Catchment Area
Figure D8-6-1-3 Cae Gwyn Monitoring Locations
Figure D8-6-2-1 Cae Gwyn Basins and Topography
Figure D8-6-2-2 Cae Gwyn Surface Water Features and Flow Directions
Figure D8-6-2-3 Water Levels below ground level Recorded in the Piezometers and Boreholes
Figure D8-6-2-4 Water Levels mAOD Recorded in the Piezometers and Boreholes

APPENDICES

Annex A Vegetation map
Annex B Borehole installation details
Annex C Peat/soil probing and coring results
Annex D Piezometer details
Annex E Nant Caerdegog Isaf flow
Annex F Piezometer logger plots
Annex G Water balance
Annex H Water quality results

About your report

The sole purpose of this report and the associated services performed by Jacobs is to assess the hydrology at Cae Gwyn Site of Special Scientific Interest, Anglesey, in accordance with the scope of services set out in the contract between Jacobs and the Client. That scope of services, as described in this report, was developed with the Client.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information collected on site, sourced from the Client, and an analytical laboratory at the times outlined in this report. Our interpretation assumes that the measured concentrations are sufficiently representative of subsurface conditions. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

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1. Introduction

Horizon Nuclear Power Ltd. is planning to develop a new nuclear power station on land west of Cemaes on Anglesey as identified in the National Policy Statement for Nuclear Power Generation [RD1]. As a Nationally Significant Infrastructure Project under the Planning Act 2008, the construction and operation of the Power Station, which is located within the Wylfa Newydd Development Area, must be authorised by a Development Consent Order.

The Cae Gwyn Site of Special Scientific Interest (SSSI) is located immediately to the west of a small part of the Wylfa Newydd Development Area, and is to the south of the majority of the Wylfa Newydd Development Area (Figure D8-6-1-1). Given the proposed construction and operational activities associated with the Power Station, there is a need to understand the functioning and sensitivities of the wetland, and in particular to ascertain whether the wetland is groundwater fed or is sustained entirely by direct rainfall and/or surface water flows. This information is used in chapter D8 (WNDA Development - Surface water and groundwater (Application Reference Number: 6.4.8)) as part of the assessment of the potential effects of the proposed development on the existing surface water and groundwater functioning at the SSSI and ultimately to investigate the potential impact on the specific nature conservation interests of the SSSI. Maps showing the location of the Cae Gwyn SSSI and its surface water catchment area are presented as figure D8-6-1-2 and figure D8-6-1-3.

Access constraints to the Cae Gwyn SSSI have limited the scope of investigations completed and the amount of data collection. The main period for which access has been allowed is November 2015 to May 2017 and so the majority of the data relates to this period. For monitoring facilities outside of Cae Gwyn SSSI monitoring data is available to August 2017.

Since November 2015, water quality data have been collected from the water environment in and around Cae Gwyn SSSI and since January 2016 shallow groundwater level data have also been collected. This report only presents the baseline conditions for Cae Gwyn SSSI based upon monitoring data from November 2015 to May 2017.

1.1 Scope and objectives

The primary objectives of this report are to:

- provide baseline data for the water environment in and around Cae Gwyn SSSI;
- review the baseline data and prepare a preliminary conceptual hydrological model that details the functioning of the SSSI;
- identify the hydrological supporting conditions critical to the maintenance of the special ecological features of Cae Gwyn SSSI; and
- review the hydroecological functioning of the site and the ecological sensitivity to changes.

1.2 Sources of information

The main sources of information used in the production of this report are shown in table D8-6-1-1.

Table D8-6-1-1 Sources of information

TYPE OF INFORMATION	DATA SOURCE
Technical Reports	• Appendix D8-1, WNDA Development - Surface water baseline report (Application Reference Number: 6.4.26). • Appendix D8-3, WNDA Development Groundwater baseline report (Application Reference Number: 6.4.28). • Wylfa Newydd Nuclear Power Station – Detailed Onshore Ground Investigation Final Interpretative Ground Investigation Report [RD2]. • Soils Site Report Full Site Report for National Grid Reference SH3591792942 [RD3]. • Welsh Lowland Peatland Survey of Cae Gwyn SSSI [RD4]. • National Vegetation Classification (NVC) summary report (includes details of Cae Gwyn NVC survey [RD5]
Published Sources	• British Geological Survey (BGS) geological maps at 1:50,000 scale [RD6]. • Cae Gwyn SSSI citation and site management statement [RD7]. • UK Technical Advisory Group on the Water Framework Directive. Draft Protocol for determining 'Significant Damage' to a Groundwater Dependent Terrestrial Ecosystem [RD8]
Fieldwork	• Observations from site visits by Jacobs hydrologists and hydrogeologists between November 2015 and May 2017, and a walkover undertaken by Jacobs ecologists in July 2013. • Surface water spot flow monitoring of Nant Caerdegog Isaf, the outflow channel of Cae Gwyn SSSI, approximately 800m downstream of the site. Carried out between February 2015 and August 2017. • Surface water continuous water level and flow monitoring of Nant Caerdegog Isaf approximately 800m downstream of Cae Gwyn SSSI between May 2015 and August 2017. • Shallow groundwater level data recorded (every 15 minutes) in piezometers installed in the Cae Gwyn basins between January 2016 and May 2017. • Groundwater level data recorded using data loggers in two boreholes in the vicinity of Cae Gwyn SSSI between March 2015 and August 2017. • Groundwater and surface water quality data – samples collected from basins, piezometers, a pond, drains, and Nant Caerdegog Isaf between November 2015 and May 2017. • Data from eight peat cores within the Cae Gwyn SSSI collected in January 2016. • Meteorological data from the Salt Survey Weather station installed on the Wylfa Newydd Development Area (February 2015 - November 2016).

1.3 Monitoring and assessment

A summary of the water environment monitoring programme for Cae Gwyn SSSI is shown in table D8-6-1-2; these monitoring locations are shown in figure D8-06-1-3.

Table D8-6-1-2 Cae Gwyn monitoring programme

GROUP	LOCATION ID	FLOW	WATER LEVEL	WATER QUALITY
Boreholes in bedrock	RGMBH13 RGMBH7	No	Groundwater loggers installed in March 2015. Downloaded quarterly.	Quarterly samples collected March, June, September and December 2015; April, August and November 2016; January/February 2017, May 2017. Samples collected using HydraSleeves (i.e. no-purge groundwater samplers)
Outfall channel/ Nant Caerdegog Isaf	CG_ OUTFALL	No	No	Sampled monthly November 2015 to April 2016 then quarterly until Mayy 2017.
Nant Caerdegog Isaf (800m downstream)	Location A	Spot flow monitoring monthly February 2015 to present;	Continuous water level monitoring May 2015 to present	Monthly monitoring November 2015 to April 2016, then quarterly until present. Continuous water quality monitoring (15 minute intervals) May 2015 – present.

GROUP	LOCATION ID	FLOW	WATER LEVEL	WATER QUALITY
		Continuous flow monitoring October 2015 to present		Data assessed to May 2017 in this report.
Basins	CG_S, CG_POB	No	No	Sampled November and December 2015 prior to piezometer installation
Piezometers	CG_PZ_S, CG_PZ_N, CG_PZ_W, CG_PZ_POB	No	Groundwater loggers installed January 2016	Samples collected February, March, May, July, November 2016 and end January/early February 2017, May 2017.
Ponds	CG_NPond	No	No	Sampled monthly November 2015 to April 2016, then quarterly until May 2017.
	CG_Well	No	No	Sampled February and November 2016 and end January/early February 2017.
Drains	CG_WDrain	Flow estimated	No	Sampled February, March and November 2016 and end January/early February 2017, May 2017.
	CG_SDrain	Flow estimated	No	
	CG_Road	Flow estimated	No	

1.4 Uncertainty and data gaps

The uncertainty and data gaps associated with the monitoring at the Cae Gwyn SSSI are outlined below.

- Monitoring at the Cae Gwyn SSSI only commenced at the end of 2015 due to access restrictions to the site and so only a relatively small amount of data is available for assessment (typically a minimum of 2 years data would be used for such an assessment). Data collection ceased in February 2017 due to further access restrictions.
- There have been constraints for site investigations at and around the SSSI, due to health and safety constraints (limitations on accessing wet / boggy areas) and land access constraints. The ground investigation was undertaken in January 2016 immediately after land access was granted, but at that time the ground was saturated and access to the centre of the basin areas was not possible. Therefore, there is only one piezometer per basin.
- There are no boreholes drilled through the SSSI and into the underlying bedrock and there are only two boreholes drilled around the SSSI, which are both drilled into a rock unit that is different to that beneath Cae Gwyn. There is therefore uncertainty regarding the thickness of the peat, what lies beneath the peat and the nature of the bedrock.
- Thick vegetation and deep water/peat prevented access to several areas.
- There were access constraints to the Cae Gwyn SSSI site resulting in the loss of one month of monitoring data. Additionally, there were significant access issues with the field to the west which contained two of the drains and a pond; therefore, only one round of monitoring has occurred at these locations.
- The groundwater logger in piezometer CG_PZ_W appeared to be ‘drifting’ and although the data have been adjusted based on manual water level dips, there may be some erroneous data. This logger was replaced in August 2016.
- The flow monitoring at Location A is for the outfall channel Nant Caerdegog Isaf, however this is 800m downstream of the SSSI and therefore monitors flows from a significantly larger catchment than just Cae Gwyn SSSI. As such, any hydrological changes at Cae Gwyn SSSI are likely to be dampened at this location and may not be apparent.

Where uncertainties or data gaps affect the quality of the assessment this is identified and the implications discussed.

2. Baseline environmental setting

The study is primarily focused on Cae Gwyn SSSI and its associated surface water catchment areas shown in figure D8-6-2-1, and has been extended to the north of the catchment area in order to encompass groundwater monitoring boreholes and a surface water monitoring location along Nant Caerdegog Isaf.

2.1 Site description

Cae Gwyn SSSI comprises a system of basin mires separated by dry heathland habitat. The topography across the area is variable with parts of the SSSI elevated above the surrounding areas. The central area of the SSSI between the northern and southern basins is elevated, the land to the north and west is lower than Cae Gwyn SSSI, whilst the land to the south-east is higher than the SSSI.

The Cae Gwyn SSSI boundary encompasses four separate basin areas; these are the Southern Basin, the Northern Basin, the Primary Outflow Basin (POB) and the Western Basin (figure D8-6-2-1). The overall main surface water catchment area of Cae Gwyn SSSI is very small, approximately 0.29km^2; this catchment includes the Northern Basin, the Southern Basin and the POB. The Western Basin has a separate surface water catchment; this has an area of approximately 0.008km^2, as shown on figure D8-6-2-1.

The elevations of the four basins are shown in figure D8-6-2-1 and given below.

- Southern Basin has a ground elevation of approximately 28m above Ordnance Datum (AOD) and generally slopes down from the south-west to the north-east.
- Western Basin has a ground elevation of approximately 24.5mAOD and is relatively flat, sloping gradually from the north to the south, with a depression in the centre.
- Northern Basin has a ground elevation of approximately 25.5mAOD and is relatively flat, sloping slightly to the south where there is a pond.
- Primary Outflow Basin (POB) has a ground elevation approximately 23mAOD, and is generally sloping down to the north-east towards the outfall channel, termed here the Nant Caerdegog Isaf.
- Nant Caerdegog Isaf at the outfall from the POB has a bed elevation of 22.2mAOD.

A steep rocky outcrop is located within the centre of Cae Gwyn SSSI, this has a maximum elevation of approximately 32mAOD. The Northern and Western Basins are separated from the Southern Basin by this rocky outcrop. The Northern Basin is separated from the Western Basin and POB by shallow rocky outcrops, which have a maximum elevation of 26.4mAOD and 25.7mAOD respectively.

In addition to the four basins listed above, in a letter to Horizon [RD9], NRW has also reported that there may be a further small basin as follows:

"*This is a small perched basin to the north of the southern basin which supports wet heath/small sedge grassland mosaic and is clearly visible on 2013 aerial photographs. This is seasonally wet but has not been identified in the report. Groundwater may be of limited importance to this area but it is part of the suite of wetlands which make up the interest of the site.*"

Due to access constraints the nature or extent of this feature has not been confirmed.

2.2 Ecological interest and management of Cae Gwyn SSSI

2.2.1 Interest features

The SSSI citation for Cae Gwyn [RD7] describes the site as two small acidic basin mires separated by a rocky heathland. This statement notwithstanding, the water quality monitoring at the site (see below) suggests that calcareous habitats are also locally important. A variety of wetland plants are found at the site, and the flora is distinguished by an abundance of the uncommon royal fern (*Osmunda regalis*), and by bog sedge (*Carex limosa*) and cranberry (*Vaccinium oxycoccos*).

A number of the plant communities recorded at Cae Gwyn form part of habitats listed under Annex 1 of the Habitats Directive. These are listed in table D8-6-2-1.

Table D8-6-2-1 Herbaceous wetland plant communities recorded from Cae Gwyn ([RD4] and [RD5]) that form part of habitats listed under Annex 1 of the Habitats Directive; communities marked with an asterisk are non-NVC communities (see [RD10])

ANNEX 1 HABITAT	PLANT COMMUNITIES RECORDED AT CAE GWYN
6410 Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae)	• M24 *Molinia caerulea–Cirsium dissectum* fen-meadow • M25 *Molinia caerulea-Potentilla erecta* mire
7210 Calcareous fens with *Cladium mariscus* and species of the Caricion davallianae	• M13 *Schoenus nigricans – Juncus subnodulosus* mire • M14 *Schoenus nigricans-Narthecium ossifragum* mire • M24 *Molinia caerulea–Cirsium dissectum* fen-meadow
7140 Transition mires and quaking bogs	• M15 Scirpus cespitosus-Erica tetralix wet heath, swampy variant* • S27 *Carex rostrata-Potentilla palustris* tall-herb fen

The Countryside Council for Wales (CCW), now Natural Resources Wales (NRW), conducted a vegetation survey of Cae Gwyn SSSI in 2005 [RD4]. A map of the communities identified is provided in annex A and the herbaceous wetland plant communities recorded in each of the four basins are listed in table D8-6-2-2. Woodland communities are not included, but stands of willow carr occur in areas, notably in the central area of the POB. The dependence of the plant communities is described in section 2.2.2. The ecology of each basin is further described in section 4.

2.2.2 Groundwater dependence of plant communities at Cae Gwyn SSSI

The Water Framework Directive (WFD) sets objectives for the protection, enhancement and restoration of the water environment including groundwater dependent wetlands. Groundwater dependent terrestrial ecosystems (GWDTE) are wetlands which critically depend on groundwater flows and/or chemistries. The UK Technical Advice Group (UKTAG) has issued groundwater dependency ratings on a scale of 1 to 3 for plant communities that are groundwater dependent [RD10], where:

1 – The community is highly dependent on groundwater.

2 – The community is moderately dependent on groundwater, and may only be groundwater dependent under certain conditions and may be less sensitive to impacts on groundwater.

3 – The community has a low dependency on groundwater and within the context of Environmental Impact Assessment is not considered to be a GWDTE.

For the communities present at Cae Gwyn SSSI an assessment has been completed based on this grading system and the groundwater dependency is listed in table D8-6-2-3 together with the UKTAG category for the relevant plant community.

Table D8-6-2-2 Herbaceous wetland plant communities recorded from Cae Gwyn ([RD4] and [RD5]); communities marked with an asterisk are non-National Vegetation Classification (NVC) communities (see [RD10]). NRW vegetation map is provided in annex A.

Basin	Plant Communities
Northern	• M23a *Juncus effuses/acutiflorus -Galium palustre* rush pasture, *J. acutiflorus* sub-community • M23b *Juncus effuses/acutiflorus -Galium palustre* rush pasture, *J. effusus* sub-community • M29 *Hypericum elodes-Potamogeton polygonifolius* soakway • M30 Related vegetation of seasonally-inundated habitats • S9b *Carex rostrata* swamp, *Menyanthes trifoliata-Equisetum fluviatile* sub-community
Western	• M16b *Erica tetralix-Sphagnum compactum* wet heath, *Succisa pratensis-Carex panicea* subcommunity • M25b *Molinia caerulea-Potentilla erecta* mire, *Anthoxanthum odoratum* sub-community
Southern	• M4 *Carex rostrata-Sphagnum recurvum* mire • M5 *Carex rostrata-Sphagnum squarrosum* mire • M6d *Carex echinata-Sphagnum recurvum/auriculatum* mire, *J. acutiflorus* sub-community • M14 *Schoenus nigricans-Narthecium ossifragum* mire • M15 *Scirpus cespitosus-Erica tetralix* wet heath, swampy variant* • M21 *Narthecium ossifragum-Sphagnum papillosum* valley mire • M24b/c *Molinia caerulea-Cirsium dissectum* fen meadow, b/c sub-community • M29 *Hypericum elodes-Potamogeton polygonifolius* soakway • S3 *Carex paniculata* sedge-swamp • S12b *Typha latifolia* swamp, *Mentha aquatica* sub-community • S27a *Carex rostrata-Potentilla palustris* tall-herb fen, *Carex rostrata-Equisetum fluviatile* sub-community • Species-rich *Carex rostrata* mire*
Primary Outflow	• M13c *Schoenus nigricans-Juncus subnodulosus* mire, *Caltha palustris-Galium uliginosum* sub-community • M23a *Juncus effuses/acutiflorus -Galium palustre* rush pasture, *J. acutiflorus* sub-community • M23b *Juncus effuses/acutiflorus -Galium palustre* rush pasture, *J. effusus* sub-community • M24a *Molinia caerulea-Cirsium dissectum* fen meadow, *Eupatorium cannabinum* sub-community • M24b/c *Molinia caerulea-Cirsium dissectum* fen meadow, b/c sub-community • M25a *Molinia caerulea-Potentilla erecta* mire, *Erica tetralix* subcommunity • M30 Related vegetation of seasonally-inundated habitats • Species-rich *Carex rostrata* mire*

Table D8-6-2-3 Herbaceous plant communities recorded at Cae Gwyn SSSI, the corresponding UKTAG GWDTE Classification (Wales), groundwater dependence scores and descriptions of hydrological supporting conditions

PLANT COMMUNITY	UKTAG GWDTE CATEGORY	DEPENDENCE OF COMMUNITY ON GROUNDWATER	HYDROLOGICAL SUPPORTING CONDITIONS
M4	Quaking bog	2	This community is characteristic of pools and seepage areas on raw peat soils of topogenous and soligenous mires where the waters are fairly acid and only slightly base-enriched. It can occur in bog pools on the surface of basin (and sometimes raised) mires, but is more common in obviously soligenous areas as in mire laggs and the wettest parts of water-tracks. Base-enrichment is slight and the pH is typically around 4. [RD11]
M5	Quaking bog	2	This community is typically found as a floating raft or on soft, spongy peats in topogenous mires and in soligenous sites with mildly acid, only moderately calcareous and rather nutrient-poor waters; the pH range is from about 4 to above 6. It is characteristically found in zonations and mosaics, the simplest being open water transitions around lakes. It can also be found around springs, seepage lines and streams where it can form part of a mixture of poor- and rich-fen communities. [RD11]
M6	Quaking bog	2	This mire is the major soligenous community of peats and peaty gleys irrigated by rather base-poor waters in the sub-montane zone of northern and western Britain. The soils and water are quite acidic with a superficial pH usually between 4.5 and 5. It typically occurs as small stands among other mire communities, grassland and heaths and sometimes with swamp and spring vegetation. [RD11]
M13	Wetland directly irrigated by spring or seepage	1	Found in and around lowland mires irrigated by base-rich, highly calcareous, and oligotrophic waters. It is often found below springs and seepage lines and on flushed margins of valley mires, but also extends into topogenous basins provided there is close contact with waters draining from lime-rich substrates. The flushing waters typically have pH between 6.5 and 8. [RD11]
M14	Wetland directly irrigated by spring or seepage	1	This community is characteristic of peats and mineral soils irrigated by moderately base-rich and calcareous ground waters of a pH range between 5 and 7. It characteristically occurs as isolated flushes among wet heath and moorland vegetation, but it is also associated with soligenous zones within valley mires. [RD11]
M15	Wet heath	2 (3)	This wet heath community is characteristic of moist and generally acid and oligotrophic peats and peaty mineral soils in the wetter western and northern parts of Britain. It is associated with thinner or better drained areas of ombrogenous peat with a surface pH typically between 4 and 5. [RD11]
M15 swampy variant	Quaking bog	2	This community, recorded by the Lowland Peatland Survey of Wales, represents a stage mid-way in the succession of topogenous poor-fen vegetation to raised ombrogenous (rainwater-fed) bog. [RD10] [RD12]
M16	Wet heath	2	This wet heath community is found on acid and oligotrophic mineral soils or shallow peats that generally have a surface pH of between 3.5 and 4.5 and that are at least seasonally waterlogged. [RD11]
M21	Wetland directly irrigated by spring or seepage / Quaking bog	2	This is a community of permanently waterlogged, acid and oligotrophic peats, especially characteristic of valley mires maintained by a locally high water table. The peat on which this community is found is usually not very deep (20-150 cm) with a surface pH mostly in the range of 3.5-4.5, and a water table at or very close to the surface. [RD11]

Plant Community	UKTAG GWDTE Category	Dependence of community on groundwater	Hydrological supporting conditions
M23	Fen (mesotrophic and fen meadow)	1 (2)	This rush-pasture community occurs over a variety of moist, moderately acid to neutral, peaty and mineral soils in the cool and rainy lowlands of western Britain. It is a community of gently-sloping ground around the margins of soligenous flushes, as a zone around topogenous mires and wet heaths, and especially widespread in ill-drained, comparatively unimproved or reverted pasture. It can be found on a variety of moderately acid to neutral soils that are kept moist to wet for most of the year with a pH in the range of 4-6. [RD11]
M24	Fen (mesotrophic and fen meadow)	2	This is a community of moist to fairly dry peats and peaty mineral soils which are circumneutral, generally having a pH within the range 5-6.5. It can be found in association with both soligenous and topogenous mires, typically marking out the better-drained fringes of bogs and fens, or the margins of wet hollows and flushes. This community is widespread through the lowland south of Britain but has become increasingly local with changes in agricultural practice. [RD11]
M29	Wetland at tufa-forming spring	2 (3)	The soakaway community occurs where water emerges from the ground and flows more or less permanently over the surface in runnels and seepages. Some stands are associated with springs or stream edges and form isolated patches within a matrix of drier grasslands and heaths. Other stands occur within mosaics of different mire types or mark out the wettest places within valley bogs. The community also occurs in peaty pools within blanket bogs. A few stands are in situations that can become dry in summer. The soils are peats or peaty gleys, and the water is acid, with a pH between 4.0 and 5.5. [RD11]
M30	Wetland at tufa-forming spring	2	Semi-aquatic vegetation of fluctuating waterbodies and their margins. The waterbody may be fed by groundwater but the community is not dependent on this supply mechanism.
S3	Swamp (oligo to mesotrophic)	3	This community is not dependent on a specific water supply, occurring in swampy areas besides lakes, canals and streams, and in areas of fens with a high water table.
S9	Swamp (oligo to mesotrophic)	3	This topogenous community is not dependent on a specific water supply, occurring in or beside a variety of water bodies, including ditches, ponds and lakes, as well as in areas of permanently deeper water within mires.
S12	Swamp (mesotrophic to eutrophic and reedbed)	3	This community is not dependent on a specific water supply, occurring in areas of standing water in ditches and other small waterbodies and in transitions to deeper open water. It is characteristic of eutrophic waters or substrates.
S27	Quaking bog	3	This topogenous community occurs in a variety of situations but is supported by moderately base-rich conditions. It frequently occurs in transitional areas of mires at the interface between soligenous/topogenous and ombrogenous communities [RD11], as well as in fens in transitions to areas with a high water table where it may form floating rafts.

Two plant communities that potentially provide a good indication of groundwater inflow and which are highly dependent on groundwater (table D8-6-2-3) are M13 and M14, both of which are present at Cae Gwyn SSSI. M13 is present in a very small area (probably of the order of 1% or less) in the central part of the POB and is surrounded by fen (M24), whilst M14 is present in a small area (approximately 1 to 2%) on the northern side of the Southern Basin. The very small areas occupied by M13 and M14 suggest that if there is groundwater inflow to the site it is potentially in limited areas, or there are only plant assemblages in limited areas that are highly dependent on groundwater. Other potentially groundwater dependent assemblages are present at Cae Gwyn SSSI, including M6, M21, M23, M24 and M30, although these are likely to have a lower dependence on groundwater than M13 and M14 (see table D8-6-2-3), but are more widespread.

2.2.3 Management and damaging operations

The Site Management Statement [RD7] states that Cae Gwyn SSSI consists of two acid wetland basins (i.e. the Northern and Southern Basins), separated by an area of heathland, and that management should maintain the current habitats across these basins. It also states that a high water table is essential for the survival of wetland plants and animals, and that no work should be carried out which would lower water levels on the site, e.g. by widening or deepening ditches. Raising water levels should not be undertaken without careful assessment. Management should maintain the current water supply to the site through springs, groundwater seepage, ditches and surface runoff; any reduction in the amount of water entering Cae Gwyn SSSI would be damaging to the site. Good water quality is also essential for the maintenance of the characteristic assemblage of wetland plants and animals at Cae Gwyn SSSI.

Grazing of the site should occur to maintain open areas of wetland; the Management Statement recommends that between three to six ponies (or cattle) be used to graze both areas of interest. NRW has indicated [RD9] that currently "*only the section of the northern basin north of the wall is open to cattle grazing at present. The north-west part of the Primary Outflow Basin (POB) has occasionally been grazed by cattle during drier weather when they can gain access through a wet area and a gap in the wall, and the south-eastern end (on a different landholding) by sheep*". Additionally, the Management Statement recommends scrub control be carried out; again this is not currently being undertaken.

2.2.4 Site condition

No formal site condition assessment of Cae Gwyn SSSI has been undertaken by NRW. However, an informal judgement is that it is in an unfavourable condition due to scrub encroachment and excessive leaf litter [RD13].

2.3 Geology and soils

This section summarises the geological setting of Cae Gwyn SSSI. A more detailed description of the superficial and bedrock geology can be found in chapter D7 Geology and soils Baseline Report (Application Reference Number: 6.4.7).

2.3.1 Bedrock geology

There are no boreholes drilled directly through the SSSI and into the underlying bedrock so the following assessment is based on information from the British Geological Survey [RD6] in addition to information from two boreholes drilled close to the northern and southern ends of the SSSI. There is therefore some uncertainty in the ground model for the site.

The bedrock beneath Cae Gwyn SSSI comprises metamorphic rocks of Cambrian age. Specifically, the SSSI is underlain by the Church Bay Tuffs and Skerries Grits, which form part of the New Harbour Group, the latter of which is found across the majority of the Wylfa Newydd Development Area. The Church Bay Tuffs and Skerries Grits comprise undifferentiated, fine-grained tuffs and sandstone, as well as interbedded layers of phyllite, schist and jasper that are characteristic of the New Harbour Group facies.

The bedrock is crossed by a number of igneous intrusions, each with a surface width of approximately 30m and a general north-west/south-east trend through the SSSI. The westernmost intrusion is comprised of gabbro and cuts into the bedrock in the far west of the SSSI. Approximately 100m east of this, and still in the south-west portion of the site, another igneous intrusion crosses both the northern and southern borders of the SSSI and intersects the Southern Basin. The third intrusion only partially extends into the north of the site and lies along the northern border of the Northern Basin.

There are two boreholes installed within the bedrock in the vicinity of the SSSI (RGMBH7 and RGMBH13). The borehole logs (provided in annex B) show that RGMBH7 is installed within a unit of coarse-grained psammite to a depth of 13.95mbgl, containing narrow bands of phyllite. The well is screened between 4-13mbgl. RGMBH13 is installed to a depth of 12.40m in slightly weathered phyllite, also belonging to the New Harbour Group. Both boreholes are installed within the New Harbour Group, but the rock units are different to those underlying the SSSI.

2.3.2 Superficial deposits

Cae Gwyn SSSI is partially covered in a layer of glacial till, deposited by successive advances of ice 12,000 to 20,000 years ago. The exact thickness of the till is unknown, although the superficial deposits across most of the Wylfa Newydd Development Area are typically less than 5m thick, with the exception of the high points of drumlins, where the till can be up to 30m thick. Based on British Geological Survey mapping [RD6] the till overlies the bedrock in the north-eastern portion of Cae Gwyn SSSI, covering just over 2ha, or about 20% of the SSSI. The rest of the SSSI is not mantled by till.

The borehole log for RGMBH7 shows that superficial deposits are absent at this location (annex B). The core from RGMBH13, however, indicates that a very thin layer of glacial till is present, overlying the bedrock at a depth of between 0.2-0.4mbgl, comprising sandy clay and cobbles.

Where the superficial deposits are present they may play an important role in the hydrology and hydroecology of the SSSI as they could result in different soil conditions and they could change groundwater / surface water interactions.

2.3.3 Soils and peat

Four piezometers were installed across Cae Gwyn SSSI in January 2016, one in each of the four basins, the locations of which are shown in figure D8-6-1-3. Fifteen soil cores were also taken across the site during the investigation carried out by Jacobs in January 2016, which identified a layer of peat across both the Southern Basin and POB, details of which are contained within annex C. The results show that mineral soils are typically found along the edges of the rocky outcrops in the site and that peat is encountered in only two of the site's basins.

Peat was absent from the Northern Basin at the locations assessed and 'CG_PZ_N' confirms the presence of shallow mineral soils up to a depth of 0.26m; this soil contained a large number of vegetation roots through the full thickness of the core Although soil coring could not be undertaken in the basin's centre, as a result of fencing restricting access to surveyors, observations made onsite indicate that peat is unlikely to be present in the remainder of the basin and that mineral soils are unlikely to be encountered to significant depth before reaching bedrock. Peat is also absent in the Western Basin and five of the soil cores, along with 'CG_PZ_W,' indicate the presence of shallow mineral soils up to a depth of 0.4m in the western portion of the basin. The core indicated a high number of roots through the upper 0.3m of the soils in the Western Basin.

In the Southern Basin, peat deposits were proven to a depth of at least 1.4m in January 2016. The centre of the basin could not be accessed due to health and safety issues, and as such, the full thickness of peat was not penetrated. The piezometric surface was above ground level and core recovery was poor (annex D). From observations made on site, the peat comprised sphagnum at the surface and the depth at which decomposed peat begins was unclear. Subsequent peat probing by NRW in July 2017 indicated that the peat thickness is substantially greater than encountered in January 2016, with NRW finding between 6 and 7m thickness of peat on the southern side of the Southern Basin, and the full thickness may then not have been penetrated.

Peat was also found in the POB, proven to a depth of 1.8m, with bedrock encountered at this depth. The centre of the POB could not be accessed due to fencing and vegetation and hence the full extent and thickness of the peat is uncertain, but it is probably greater than 1.8m. The peat core recovered from the piezometer comprised a fibrous, poorly decomposed, silty peat with high moisture content throughout, becoming more decomposed in the lower half of the core (annex D). A second core, recovered during the peat probing exercise, showed a similar composition of peat, but with a lighter, more mineral soil in the top 0.2m of the core (annex C).

2.4 Hydrology

2.4.1 Surface water flow routing

Based upon the topography there are two distinct catchments within Cae Gwyn SSSI. Within the larger catchment are the Southern Basin, the Northern Basin and the POB; the water features and flow pathways within this catchment are shown on figure D8-6-2-2 and described below.

- The Southern Basin receives surface water inflows from the surrounding catchment and drains to the Primary Outfall Basin via an incised channel, referred to here as the Southern Drain.
- A small drain flows into the Southern Basin and is referred to here as the Road Drain, so named as a local farmer indicated that it was fed partially by runoff from the road; this watercourse is not shown on Ordnance Survey (OS) mapping. The Road Drain has been culverted within the field to the south-west, and may incorporate flows from a well shown on OS mapping, as well as some road drainage.
- There is a large pond to the south of the Southern Basin marked as a well on OS mapping.
- The Northern Basin receives surface water inflows from a small surrounding catchment and does not have a formalised flow pathway to the POB. However, based upon the topography it appears that if water levels within the Northern Basin were to rise beyond a point, overland flow towards the POB would occur.
- There is a relatively large pond located within the Northern Basin. This is referred to here as the Northern Pond.
- Based upon the topography and site walkovers, the POB receives water from the Southern Basin, and in wet periods potentially from the Northern Basin.
- Within the POB there are some minor field drains which cross the basin; these are likely to have been dug to drain the adjacent field and are referred to here as the Outfall Drains.
- The POB, and therefore the Southern and Northern Basins, are all drained by Nant Caerdegog Isaf.

The Western Basin is within a small catchment separate from the rest of Cae Gwyn SSSI. The basin is relatively flat, with a depression in the centre, but eventually drains from the site via the Western Drain, as shown on figure D8-6-2-2. The Western Drain drains to a minor tributary of the Afon Cafnan referred to here as the Nant Llanddygfael, which discharges to the Afon Cafnan approximately 0.9 km upstream of Nant Caerdegog Isaf.

2.4.2 Walkover surveys

The site walkover surveys in November 2015, January 2016 and general observations made on a monthly basis while collecting data since then have been used to develop the baseline understanding of surface water flow routes, including information on the Road Drain. Observations of flows between the basins are outlined below.

- The Southern Basin is an elevated peat surface, with *Sphagnum* at the surface, as shown in plate 1. The surface was observed to be slightly domed, however access was restricted from the centre so the amount of doming could not be quantified.
- The Northern Basin comprises an elongated area incorporating reeds and rushes, as shown in plate 2. The Northern Basin also incorporates a small and shallow pond.
- The POB is boggy, flat land with grass and reeds (plate 3), however this bog ‘quaked’ during the wetter months. The boggy area was to the north and west of the basin, while the southern area incorporates some man-made ditches and is well drained. There is a significant block of willow carr in the centre of the POB, while the north-western area has extensive grass and rush communities.
- The Western Basin comprises two circular depressions with a coarse grass covering (plate 4).

Plate 1 View north-west across the Southern Basin (November 2015)

Plate 2 View west across Northern Basin (January 2016)

Plate 3 View south-east across POB (November 2015)

Plate 4 View west across Western Basin (November 2015)

- The Western Drain was observed and sampled during walkovers. The drain was wet during the winter months, however the water was largely static with minimal flows along the drain (plate 5). The Western Drain dried up during the summer months, and no sample could be obtained in August 2016.
- The connection of the Southern Drain from the SSSI to Nant Caerdegog Isaf could not be observed during the walkovers due to the thick vegetation in the area (plate 6). Nant Caerdegog Isaf at the SSSI boundary was observed to be overly wide and deep (compared to the volume of water that flows along the channel), which meant that flow was imperceptible even during the wetter winter months. The width and depth of the channel meant that spot flow monitoring was not possible as it was unsafe to enter the water.
- The Southern Drain (outflow from the Southern Basin) was only observed in winter and autumn months (January, February, October and November 2016, January 2017) due to land access constraints. Additionally, there was no access to the bank of the Southern Drain as it is fenced off. The north of the Southern Basin was observed to be different in character from the rest of the basin, and appeared to be a wetland (plate 7). The Southern Drain flows from this area and flows adjacent to the field boundary (beyond the fence) in a north-easterly direction. The channel is sinuous and shallow with a gravel sized substrate. At the northern extent of the SSSI the channel flows north-west; the channel could not be observed beyond this point. The flow has been visually estimated (from the opposite side of the fence) to range between approximately 15l/s immediately following a rainfall event to 0.3l/s under drier conditions. It appears that the larger flows are only present immediately following rainfall events and are not representative of general conditions.
- During the January 2016 site walkover the owner of the field adjacent to the A5025 into the north of the Southern Basin stated that the Road Drain forms part of the A5025 road drainage. The A5025 in this area drains to two rocky soakaways which are downgradient of the road. The water from these flows via soils/superficial deposits towards the drain. The drain is culverted through the field prior to flowing along a field boundary and into the Southern Basin (plate 8). Flows within the Road Drain were estimated to range between approximately 0.2l/s and 8l/s. Given that the origin of this watercourse is from below ground, there is potential that the drain may incorporate some spring flows, however this cannot be confirmed.

- Flow from the Northern Basin to the POB was not observed during any walkover; therefore it is unlikely that this occurs regularly, and any flow that does occur is overland rather than via a formal drainage system. This area was boggy in January and February 2016.

Plate 5 Western drain view west (January 2016)

Plate 6 View towards Nant Caerdegog Isaf (August 2016)

Plate 7 Southern Basin flowing into Southern Drain (January 2016)

Plate 8 Drain from A5025 flowing to Southern Basin, view south (January 2016)

2.4.3 Flow data

There are no flow data from within Cae Gwyn SSSI due to access and safety restrictions; additionally Nant Caerdegog Isaf was unsafe to access immediately downstream of the site due to steep banks and an artificially overdeepended channel with a bed comprising extremely soft sediment. The absence of flow data for the outflow from the Cae Gwyn SSSI introduces a degree of uncertainty into the assessment. This is discussed further as part of the water balance assessment below.

Flow data have been gathered from Nant Caerdegog Isaf approximately 800m downstream of Cae Gwyn SSSI since November 2014 at Location A shown on figure D8-6-1-2**Error! Reference source not found.**. The surface catchment at Location A is approximately 0.64km^2, which is just over twice the size of Cae Gwyn SSSI catchment draining to it.

Spot flow monitoring has been undertaken approximately monthly since November 2014 at Location A. Spot flow monitoring along Nant Caerdegog Isaf has recorded flows of between 0.02l/s in August 2016 and up to 75l/s in December 2015 (annex E). This shows the high variability of flow along this watercourse. Spot flow gauging data indicates that flows in the stream are highest in December and March and lowest in late summer and early autumn (August to November).

A stilling well was installed on Nant Caerdegog Isaf at Location A in May 2015, which records the water level at 15 minute intervals. In October 2015 a flume was also installed at this location; this allows the water level to be converted to flow. A plot of the spot flow gauging and the continuous flow data is shown in annex E.

Data recorded at location A indicates that flows rapidly increase in response to the extreme rainfall events experienced between December 2015 and March 2016. The maximum recorded flow is over 160l/s, however this is outside of the flume's maximum specification of 100l/s and so is indicative. During this period, flows remain high (more than 20l/s) between the exceptionally high peak flows possibly due to the short period of time between storms during this extremely wet winter. The flume and water level gauge did not accurately capture flows in the summer of 2016; this is likely due to high flows in winter altering the river bed in front of the flume causing an artificially deepened pool upstream of the flume at the location of the stilling well. Therefore, during the monthly visits spot gauging was completed and compared to the volume measured by the flume. Where necessary this was used to calibrate the flume for that month so that the flow measured by spot gauging was the same as that measured by the flume. The ratio between these figures was then used to adjust the 15 minute flow for the month.

The flows recorded during the winter of 2016/2017 also show very high peaks as a result of heavy rainfall. However, peaks are more widely spaced and flows return to close to summer levels in between rainfall events. The summer of 2017 experienced relatively high flows compared to the summer period during 2016.

The flow data for Nant Caerdegog Isaf and for other watercourses across the Wylfa Newydd Development Area are discussed further in appendix D8-1 (Application Reference Number D8-1). The data in this report show that in the summer months Nant Caerdegog Isaf has a smaller flow per unit of catchment area than other monitored locations within the Wylfa Newydd Development Area. However, in the winter months the flow along the watercourse can be significantly higher per unit area than for the other locations. This suggests that during the summer months there is less base flow than in other watercourses in the area, potentially indicating retention of rainfall in Cae Gwyn SSSI. During the winter months there is a significant groundwater input along the stream. This is corroborated by the flow gauging at Location A which indicates that during the summer there is very low baseflow, while in the winter the base flow appears to increase along with the storm peaks. This indicates that there is a very low groundwater input to the watercourse in the summer, which increases significantly during the winter months, albeit based on limited data.

2.5 Hydrogeology

2.5.1 Groundwater monitoring

A comprehensive groundwater level and water quality-monitoring programme exists for the Wylfa Newydd Development Area. This includes over 100 groundwater-monitoring installations and logger data from each of these boreholes has been used in the production of groundwater contour plots to illustrate groundwater levels throughout the site. Details of the borehole installations are provided in appendix D8-3 (Application Reference Number: 6.4.28).

There are two groundwater monitoring boreholes installed within the vicinity of Cae Gwyn SSSI. Both boreholes (RGMBH7 and RGMBH13) are installed within the shallow/weathered bedrock of the New Harbour Group to depths of 13.95m below ground level (mbgl) and 12.40mbgl, respectively. Installation details are summarised in annex B and borehole locations are shown in figure D8-6-1-3.

In addition to the groundwater monitoring boreholes, water level loggers were installed within piezometers (CG_PZ_S, CG_PZ_W, CG_PZ_N and CG_PZ_POB) installed into the peat and soils within the four basins identified in Cae Gwyn SSSI. Installation details are shown in annex D, along with the results of the peat/soil coring and probing, with the locations shown on figure D8-6-1-3.

2.5.2 Groundwater levels and flow

There are no data available for groundwater levels within the Cae Gwyn SSSI, with the exception of the four piezometers that measure shallow water levels in shallow peat and soil. There are no boreholes into the superficial deposits or bedrock within the SSSI and so the assessment below is based on interpolation between two boreholes that are outside of the SSSI. This therefore introduces uncertainty into the assessment, and in the absence of any other information, the interpolation is presented here as an indication of what might be happening beneath the site.

The groundwater contour plots generated for the Wylfa Newydd Development Area, contained within appendix D8-3 (Application Reference Number: 6.4.28), show that the dominant groundwater flow direction at Cae Gwyn SSSI is towards the north-west and the coast at Cemlyn Bay. This direction is based on data across a large area and there is only limited data around the Cae Gwyn SSSI. There may therefore be changes in the water table local to the SSSI which are not apparent at the regional scale. These could, for example, be due to the effect of local features, such as the igneous intrusions in the southern portion of the SSSI. These could act in different ways, including: as barriers to groundwater flow; as preferential pathways; or they could have no effect on flows beneath the SSSI. Each of these would affect the water level and flow direction in a different way.

Groundwater level monitoring in boreholes RGMBH7 and RGMBH13 between January 2016 and August 2017 indicates that bedrock groundwater levels in the New Harbour Group (psammite at RGMBH7 and phyllite at RGMBH13) were at their lowest in August and September 2016 with maximum levels recorded in January 2016. However, from year to year the actual peak and minimum water level is variable and is closely linked to rainfall patterns. Water levels in the two boreholes respond very differently over the monitored period, with average winter to summer water levels at RGMBH7 fluctuating by only 0.5m, compared to a more notable fluctuation of 3.6m at RGMBH13 (see table D8-6-2-3). Between January and April 2016, groundwater levels at RGMBH13 are generally shallower than at RGMBH7, whereas in the summer months, between May and September, groundwater levels at RGMBH13 fall (ranging from 1.0-4.6mbgl), compared to RGMBH7 (where groundwater levels range from 2.4-2.6mbgl). This could indicate that groundwater levels in RGMBH7 are in continuity with the stream at this location such that water level fluctuations are limited due to being controlled by the stream level which is at approximately 22mAOD, 2.6m below the borehole ground level. It is also possible that the igneous intrusions that are present across the SSSI mean that the two boreholes are in separate blocks of aquifer and respond differently to recharge.

Maximum winter groundwater levels in the New Harbour Group are provided in table D8-6-2-4 and range from 22.9mAOD at RGMBH7 (north-east of the site) to 30.7mAOD at RGMBH13 (to the south). Ground elevations in each of the four basins at the piezometer locations are also given for comparison.

2.5.3 Water levels in the peat and soils

As stated, one piezometer was installed into the peat and soils in each of the four basins in January 2016 and these locations were surveyed to Ordnance Datum and National Grid. Groundwater level loggers were installed to record water levels at 15-minute intervals. The piezometer logger data, along with the borehole data, are shown in figure D8-6-2-3 and figure D8-6-2-4 and summarised in table D8-6-2-4. Further detailed plots are contained in annex F.

Between January and March 2016, the water level in the Southern Basin remained at or just above ground level. A steady decline in water level is then observed between March and August, followed by an equally steady rise back to above ground level in August 2016 to February 2017. The maximum variation in water level throughout the year is in the order of 0.30m (see table D8-6-2-4), although several notable responses to rainfall events are observed in late July, mid-August, late September and late November/early December, with rises in water level in the order of 0.10m for each event. These responses are attributed to the wetting-up phase of the peat.

The gradual decline in water level between March and August 2016 could be the result of a number of factors including flow along the Southern Drain, a reduction in any groundwater inflow into the basin due to the bedrock water table dropping below the basin floor, leakage to groundwater from the peat, as well as evapotranspiration from the basin surface, creating a soil moisture deficit in the peat. In the winter months, any inflowing water (direct rainfall, surface water runoff and groundwater) which exceeds that being lost from the basin will likely be used to recharge this deficit. The plateau observed in water levels in January/February 2016 and again in December 2016 to February 2017 (in all four basins) suggests that there are no further increases in water level in the winter months as the basins are likely to be overflowing at the surface. In the Southern Basin, this is attributed to the Southern Drain transporting excess flows to the POB (see Section 2.4.2) in winter.

Table D8-6-2-4 Borehole and piezometer water levels in Cae Gwyn SSSI (January 2016 to February 2017)

Piezometer/ Borehole	Geology/ Soils	Piezometer/Borehole		Recorded absolute water level (mAOD)		Range (m)	Average water level (mAOD)	
		Ground Level (mAOD)	Level of Borehole Base (mAOD)	Summer Low[1]	Winter High[2]		Summer Low[3]	Winter High[3]
RGMBH7	Bedrock	24.65	13.95	22.41	22.94	0.53	22.4	22.7
RGMBH13	Bedrock	31.69	12.40	27.07	30.66	3.59	27.7	29.9
CG_PZ_S	Peat	27.82	26.62	27.59	27.89	0.30	27.7	27.8
CG_PZ_W	Mineral	24.62	24.22	24.25	24.69	0.44	24.4	24.6
CG_PZ_N	Mineral	25.61	25.37	25.40	25.69	0.29	25.4	25.6
CG_PZ_POB	Peat	22.88	21.15	22.26	22.96	0.70	22.5	22.9

[1]Absolute summer low is minimum water level from loggers in August/September 2016

[2]Absolute winter high is maximum water level from loggers in January 2016/March 2016/November 2016/December 2016

[3]Average summer low and winter high are average water levels from August/September 2016 and December 2016, respectively

The water level in the POB shows a similar trend to that observed in the Southern Basin, including the responses to the rainfall events observed in late July through to early December 2016 (similar responses are also observed in the Northern and Western Basins), suggesting that the water levels in the two basins function in a similar way. However, water levels in the POB show a greater response to rainfall events, with an overall variation throughout the year of around 0.70m (see table D8-6-2-3), more than double that of the Southern Basin. In addition, the water level remains at ground level until late April 2016, compared to early March for the Southern Basin, showing a two-month lag in the POB response. This indicates that either the POB receives a more sustained inflow (groundwater or runoff) in the winter/spring months than the Southern Basin, the greater depths of peat in the POB are able to retain greater quantities of water, or the high bedrock groundwater table at the POB prevents drainage of the peat into the underlying bedrock.

From May 2016 onwards, once the drying out phase has started, water levels in the POB decline more rapidly than in the Southern Basin, despite being able to initially retain more water. This could be due to groundwater levels in the bedrock dropping below the basin floor and allowing downward drainage through the peat and into the underlying aquifer. This is reflected in the flows in the Nant Caerdegog Isaf, which significantly reduce in the summer/autumn months. As described in Section 2.4.3, the Nant Caerdegog Isaf has a small base flow component in summer, compared to other watercourses in the area. Given that the watercourse is the primary outflow from the POB, the decline in piezometer water levels through the summer/autumn could be the result of water exiting the basin via another route, i.e. drainage of the peat into the bedrock. Water levels in the POB do remain above 22mAOD, which is the surveyed level of the stream bed, and therefore it is likely that flows in the watercourse continue through the summer, fed by the POB and groundwater in the surrounding bedrock.

The water level variations in the Northern and Western Basins follow a broadly similar trend to those observed in the Southern Basin and POB with water at ground level in winter, dropping in spring and summer. During the late spring/early summer months, water levels in these two basins show a steady decline, with a limited store of water in the soil and subsoil and groundwater levels in the bedrock at a lower elevation than the basin floors. However, from June through to October 2016, water levels in the Northern Basin appear to remain relatively steady, at a depth of around 0.2mbgl, which indicates that the basin is dry, and with limited recovery in early autumn. It isn't until mid-November that water levels in the Northern Basin begin to rise steadily back to ground level, responding in a similar manner to the other basins to the rainfall events in late November/early December 2016. It should be noted that water levels within the Northern Basin remain below the level of the elevation of the overflow point (25.7mAOD), which could indicate that levels above this would overflow the basin.

Water levels in the Western Basin show a more flashy response to rainfall, with a recession period of one to two days for larger rainfall events. Between January and August 2016, discrepancies exist between the water levels recorded by the logger and the manual dips collected from the piezometer in the Western Basin. Level data recorded by the logger over this eight-month period have therefore been discounted and only manual dips have been used to draw conclusions on the hydrological functioning of the Western Basin.

2.6 Water balance and water levels

Based on the meteorological data collected in the Wylfa Newydd Development Area, a high level water balance for each of the basins has been undertaken for the period between mid-January 2016 and mid-November 2016. This has been completed to estimate changes in water volume within each basin in order to support the hydrological conceptual model for each basin and is presented in Appendix G.

The limitations of the data sets used to create this water balance are considerable and are discussed in annex G. However, it is considered to provide a useful supporting information in the conceptualisation of the site. Overall, the water balance indicates that surface water runoff and direct rainfall are the most important sources which maintain the wetland status of the site. However, limitations and uncertainties with the methodology mean that it is still possible that groundwater inputs are important locally. The interpretations of the water balance for the four basins are summarised below.

2.6.1 Southern Basin

The water balance found that inflows generally exceeded outflows indicating that it is unlikely that there are any substantial groundwater inflows to the Southern Basin. However, there could be substantial outflows to groundwater during winter and autumn.

2.6.2 Northern Basin

The available data indicates that there are larger inflows to the basin than outflows, and generally these do not correspond to an overall increase in water level within the basin. This is interpreted as indicating that there are losses from the basin, likely due to a combination of an informal overland flow route to the POB and losses to groundwater. In the winter it is likely that there are significant losses via overland flow (overflowing once the level reaches 25.7mAOD) given the relative surveyed land levels and observed boggy areas downstream of the basin.

2.6.3 Primary Outflow Basin

The water balance indicates that for the whole monitoring period inflows are almost the same as ouflows and does not suggest that there are any substantial inflows or outflows that are unaccounted for. However, there are significant monthly differences, the most notable of which are those in January and February 2016 when, unusually for winter, the outflows exceed the inflows, which could indicate groundwater inflow and overland flow from the Northern Basin. There is also a greater outflow than inflow in May, June, July and August 2016 although this is likely due to a different mechanism as in this period rainfall recharge was low and the POB was likely draining, although this is not consistent with the measured change in water levels. The difference between inflows and outflows could also be associated with inaccuracies in the water balance.

2.6.4 Western Basin

The Western Basin is small, and therefore the water volumes are less significant to Cae Gwyn SSSI than for the other basins. For the monitoring period as a whole, and with the exception of May 2016, the outflows exceed the inflows suggesting that there is either an inflow of groundwater to the basin, or that there is overland flow from the basin to the Western Drain. The imbalance is likely due to a combination of these. In May 2016 the water balance indicates very slightly more outflows than inflows, which corresponds to the reduction in water level during this month. In the summer months (May to August 2016) the water balance is close to being neutral indicating that there are no significant unrecorded inflows or outflows during this period.

2.7 Water quality

The quality of water flowing into Cae Gwyn SSSI is one of the key hydrological supporting conditions for the wetland, according to the SSSI citation. In response to this, water quality sampling has been carried out in the Cae Gwyn surface water catchment since November 2015, the results of which are presented in annex H. All sampling locations are shown on figure D8-6-1-3. The water quality data is limited in terms of the number of locations sampled and the time period over which data are available, but they do provide an indication of the likely water quality at the scale of the SSSI. The data do not provide details of water quality at a scale associated with particular vegetation assemblages and should not be considered representative of such areas.

2.7.1 Field parameters

Field parameters have been recorded in both surface water and shallow groundwater samples, summarised in table D8-6-2-5, with the full dataset in annex H.1. Data collection is skewed towards the winter and spring months, due to the fact that the field monitoring programme started in November 2015, that access to many locations was limited to winter months only, and that many of the surface water features had dried up in the summer months.

Table D8-6-2-5 Summary of Field Parameters recorded between November 2015 and August 2017

Sample ID	#		pH	Elec. Cond. µS/cm	Dissolved Oxygen %	Redox mV	Temperature °C	Turbidity NTU
Surface Water Locations								
CG_Outfall	11	min	5.9	238	31	37	4.9	5
		max	7.8	570	92	519	16.2	25
		average	6.8	345	62	89	11.2	10
CG_ODrain	3	min	6.7	227	29	-84	9.1	5.0
		max	7.1	758	88	79	16.5	500
		average	6.9	438	51	19	11.6	252
CG_POB	1	Recorded	6.9	256	-	12	10.3	-
CG_S	2	min	5.5	208	65	14	10.8	-
		max	6.9	216	65	94	13.0	-
CG_NPond	9	min	5.6	126	16	-44	4.3	6
		max	7.7	483	160	582	20.6	200
		average	6.6	243	84	102	11.7	56
CG_SDrain	6	min	5.3	186	58	33	4.7	<5
		max	8.0	289	100	468	13.5	100.0
		average	6.6	225	85	117	8.5	34
CG_Road	6	min	5.3	310	66	32	6.0	5
		max	7.8	396	101	437	13.6	45
		average	6.6	337	92	107	9.1	14
CG_WDrain	5	min	5.0	117	24	9	5.6	5
		max	6.8	355	101	612	12.2	15
		average	6.2	293	75	140	8.7	8
CG_Well	5	min	5.6	66	26	39	3.6	5
		max	7.8	217	100	466	11.6	35
		average	6.4	113	65	109	8.1	17
Piezometers								
CG_PZ_POB	8	min	5.4	73##	18	-107	6.8	510
		max	7.7	640	102	500	16.0	510
		average	6.7	428	50	14	11.6	510
CG_PZ_S	9	min	5.0	235	13	-35	6.0	140
		max	6.6	496	103	499	16.9	400
		average	6.1	381	39	44	10.8	270
CG_PZ_N	6	min	6.0	160	25	-49	3.9	5
		max	7.0	391	101	376	13.8	500
		average	6.5	256	44	45	9.6	188
CG_PZ_W	8	Min	5.0	112	16	-35	3.3	5
		max	7.4	314	101	416	15.5	500
		average	6.2	205	43	86	10.2	170

Sample ID	#		pH	Elec. Cond. µS/cm	Dissolved Oxygen %	Redox mV	Temperature °C	Turbidity NTU
Boreholes**								
RGMBH7	6	Min	7.7	413	-	-	-	-
		Max	8.3	497	-	-	-	-
		Average	8.0	462	-	-	-	-
RGMBH13	7	Min	6.9	350	-	-	-	-
		Max	7.9	494	-	-	-	-
		Average	7.4	411	-	-	-	-
# refers to the number of samples taken. ** Lab results have been used for groundwater samples. ## suspect reading, possibly equipment failure								

Table D8-6-2-5 indicates that the pH of water from the surface water channels, ponds and drainage ditches is generally neutral to slightly acidic. The pH of the water collected from the piezometers is also neutral to slightly acidic, but is slightly more acidic than the surface water. This is in line with the SSSI citation for Cae Gwyn, which describes the special features as a series of acidic wetland basins. This notwithstanding, the data do demonstrate occasions when slightly alkaline conditions are present suggesting that calcareous habitats may also be important in parts of Cae Gwyn SSSI. This is further assessed below.

Electrical conductivity readings for all samples are within the range for fresh water, although the values vary both spatially and temporally. Dissolved oxygen levels are, as would be expected, consistently lower in the piezometers than the surface water features, indicating less aeration of shallow groundwater within the basins.

The “well” adjacent to the Southern Basin was observed to have high dissolved oxygen and low conductivity, indicating that it is likely to be a surface water feature rather than groundwater fed, and therefore is more accurately a pond. Additionally, the Road Drain has a high conductivity indicating some groundwater input.

Redox levels are generally moderate to high for all samples (surface water and water collected from the piezometers) during the winter months. Redox values are low or negative for the piezometer samples in summer, while remaining moderate in surface water. The Fen Management Handbook [RD14] states that redox values between 40mV and -20mV are indicative of anaerobic conditions in peat bogs. This is consistent with slow-moving or event stagnant waters. The results indicate that during winter, water is flowing through the surface water features and within the basins, while in the summer the flow within the basins slows.

2.7.2 Ionic balance

Ionic balances were completed by the laboratory for all samples collected during the study period using concentrations of calcium, magnesium, sodium, potassium, ammoniacal nitrogen, bicarbonate alkalinity, nitrate and sulphate. The results are summarised in table D8-6-2-6.

The majority of samples had a maximum error of up to ±10% indicating that both the surface water and piezometer samples were stable and approaching equilibrium. Sample locations CG_Outfall, CG_NPond, CG_SDrain and CG_PZ_N each had one sample which displayed a greater error (13%, -11.2%, 11% and 12%, respectively).

Table D8-6-2-6 Summary of Ionic Balances

Sample ID	Max Error %	Min Error %	No. of Positive Errors	No. of Negative Errors	No. of Errors >±10%
Surface Water Locations					
CG_Outfall	13	-10	2	8	1
CG_ODrain	0.5	-4	1	2	0
CG_POB	4	-8	3	3	0
CG_S	20	-15	2	5	1
CG_NPond	6	-11	3	4	0
CG_SDrain	11	-1	3	2	1
CG_Road	0.3	-6	1	2	0
CG_WDrain	1.2	-1	1	1	0
Piezometers					
CG_PZ_POB	4	-8	3	3	0
CG_PZ_S	20	-15	2	5	1
CG_PZ_N	12	-5	3	2	1
CG_PZ_W	6	-7	0	2	0

Note: all ionic balances provided by the analytical laboratory

2.7.3 Inorganic analyses

In samples from watercourses, ponds, drainage ditches and piezometers, concentrations of major ions are generally low (total dissolved solids <450mg/l), with the exception of one sample taken from the POB piezometer in February 2017, which has a total dissolved solids concentration of 1,800mg/l. The shallow groundwater monitored in the piezometers in the Southern Basin and POB, and surface water along Nant Caerdegog Isaf (at Location A and in CG_Outfall) generally shows similar water quality, which may indicate that groundwater and surface water in these locations are in hydraulic connection.

Calcium concentrations in samples taken from the POB piezometer are also very high in comparison to samples taken from the other piezometers and are similar to that observed in RGMBH7, which would suggest that the POB receives groundwater inflow. As noted above, this suggests that Cae Gwyn SSSI is not wholly an acid mire and there are species present that are more reliant on calcareous conditions.

Water quality is summarised in table D8-6-2-7, with raw data presented in annex H.2.

Table D8-6-2-7 Summary of inorganic laboratory water quality results

Sample ID	no.		Alkalinity (Total) mg/l) mg/l	Total dissolved solids mg/l	Ammoniacal nitrogen N (mg/l)	Sulphate mg/l	Chloride mg/l	Nitrite as NO_2 mg/l	Nitrate as NO_3 (mg/l)	Total suspended solids mg/l	Phosphate (ortho) as PO_4 mg/l	Tot.Phosphorus µg/l
Surface Water Locations												
CG_Outfall	11	Min	60	182.00	0.20	2.0	43.8	0.05	0.30	3	0.05	36
		Max	160	358.00	7.19	41.0	78.7	0.05	13.30	2580	0.26	11300
		Average	108	262.27	0.90	15.7	60.2	0.05	3.63	494	0.08	1676
CG_ODrain	3	Min	105	259.00	0.20	2.0	32.4	0.05	0.30	23	0.05	182
		Max	215	351.00	0.28	25.7	61.0	0.06	13.10	1190	0.09	6240
		Average	178	317.00	0.23	10.0	48.1	0.05	4.57	454	0.06	2380
CG_POB	2	Min	55	258.00	0.20	2.0	31.9	0.05	0.30	2	0.26	16000
		Max	140	345.00	0.61	10.0	45.7	0.50	20.40	3440	0.26	16000
		Average										
CG_S	2	Min	5	175.00	0.20	2.0	48.0	0.05	0.30	9	0.00	0
		Max	11	226.00	0.63	63.1	71.6	1.00	0.30	1060	0.00	0
CG_NPond	8	Min	5	137.00	0.20	2.0	43.1	0.05	0.30	3	0.06	69
		Max	135	431.00	14.40	45.5	88.8	0.25	3.00	2330	6.72	4720
		Average	45	236.50	3.32	9.7	63.3	0.12	1.21	347	1.78	1129
CG_SDrain	5	Min	5	148.00	0.20	2.0	46.9	0.05	0.30	9	0.05	37
		Max	55	226.00	0.63	63.1	71.6	1.00	0.79	1060	0.05	1030
		Average	30	182.20	0.29	14.2	57.1	0.24	0.40	419	0.05	369
CG_Road	3	Min	95	232.00	0.20	12.1	49.0	0.05	1.14	6	0.05	26
		Max	110	402.00	0.20	19.3	86.3	0.05	4.88	24	0.05	61
		Average	102	307.00	0.20	16.8	63.8	0.05	2.78	17	0.05	46
CG_WDrain	3	Min	8	167.00	0.20	2.0	45.7	0.05	1.95	2	0.05	396
		Max	55	301.00	0.20	16.7	65.9	0.25	20.40	1910	0.09	2800
		Average	25	200.00	0.20	3.6	51.7	0.05	7.55	54	0.05	396
CG_Well	2	Min	20	55.60	0.20	2.0	23.5	0.05	0.30	126	0.05	336
		Max	20	94.40	0.20	2.0	24.3	0.05	0.30	2100	0.05	1210
Piezometers												
CG_PZ_POB	9	Min	55	200.00	0.20	2.0	41.2	0.05	0.30	274	0.05	163
		Max	275	1810.00	34.30	94.0	52.4	0.50	11.60	3920	0.06	6180
		Average	190	534.14	5.26	20.7	44.8	0.12	2.06	1968	0.05	2065
CG_PZ_S	6	Min	28	166.00	0.20	2.	5.3	0.05	0.30	135	0.05	79
		Max	110	361.00	0.56	20.00	58.9	0.50	0.30	464	0.05	304
		Average	82	260.63	0.25	5.4	49.9	0.11	0.30	300	0.05	181
CG_PZ_N	6	Min	7	126.00	0.20	2.0	42.9	0.05	0.30	6	0.05	595
		Max	16	162.00	1.53	2.0	59.0	1.00	1.07	1920	0.69	1820
		Average	11	140.17	0.52	2.0	49.5	0.32	0.48	673	0.18	1055
CG_PZ_W	5	Min	2	103.00	0.20	2.	27.6	0.05	0.30	109	0.05	496
		Max	8	178.00	3.35	10.7	57.6	1.00	1.50	4400	0.05	4180
		Average	6	136.67	0.73	4.4	40.9	0.32	0.70	1301	0.05	2279

Sample ID	no.		Calcium mg/l	Magnesium mg/l	Manganese µg/l	Potassium mg/l	Sodium mg/l	Iron mg/l
Surface Water Locations								
CG_Outfall	10	Min	24.00	5.45	3.27	1.57	20.50	0.03
		Max	47.20	19.90	606.00	4.10	36.00	3.27
		Average	36.14	10.05	219.32	2.72	29.64	0.66
CG_ODrain	3	Min	47.30	8.65	932.00	2.33	22.90	0.25
		Max	66.00	12.30	932.00	4.81	30.00	21.50
		Average	58.50	10.58	932.00	3.64	26.57	7.95
CG_POB	1	Min	25.40	6.42	-	2.57	14.00	0.16
		Max	39.30	6.88	-	4.41	18.90	6.08
		Average						
CG_S	2	Min	6.26	3.51	-	2.46	21.80	0.35
		Max	19.50	7.65	-	2.70	37.50	2.01
CG_NPond	7	Min	3.73	2.85	-	1.95	24.20	0.45
		Max	12.20	8.19	-	43.20	36.40	6.43
		Average	7.70	5.03	-	17.46	30.24	2.09
CG_SDrain	3	Min	6.26	3.51	-	1.00	21.80	0.08
		Max	23.10	9.12	-	2.94	42.50	2.01
		Average	15.73	5.57	-	2.02	30.46	0.57
CG_Road	3	Min	32.00	5.84	-	1.00	28.50	0.02
		Max	43.90	7.60	-	1.59	48.70	0.07
		Average	38.33	6.56	-	1.23	35.57	0.04
CG_WDrain	2	Min	5.34	3.90	-	4.36	18.90	0.16
		Max	25.40	6.42	-	4.41	30.20	0.35
		Average	12.33	4.61	-	3.74	23.63	0.84
CG_Well	2	Min	6.08	2.04	-	1.00	13.80	0.28
		Max	7.62	2.33	-	1.00	14.90	0.68
Piezometers								
CG_PZ_POB	9	Min	20.30	5.79	-	1.00	17.80	0.02
		Max	83.00	10.90	-	9.18	29.00	30.20
		Average	60.50	8.13	-	3.88	24.60	11.82
CG_PZ_S	6	Min	14.20	4.52	-	1.00	18.50	1.99
		Max	30.00	8.08	-	1.00	22.90	76.80
		Average	25.30	6.96	-	1.00	21.73	38.16
CG_PZ_N	6	Min	3.45	2.29	-	1.00	20.30	0.44
		Max	11.80	5.37	-	3.48	30.10	47.10

Sample ID	no.		Calcium mg/l	Magnesium mg/l	Manganese µg/l	Potassium mg/l	Sodium mg/l	Iron mg/l
		Average	5.91	3.27	-	2.31	24.20	14.41
CG_PZ_W	5	Min	2.38	2.01	-	1.00	15.80	0.37
		Max	5.04	3.98	-	1.43	23.90	19.60
		Average	3.39	2.56	-	1.14	19.28	8.20

Sample ID	no.		Alkalinity (total) mg/l	Total dissolved solids mg/l	Ammoniacal nitrogen N (mg/l)	Sulphate mg/l	Chloride mg/l	Nitrite as NO_2 mg/l	Nitrate as NO_3 (mg/l)	Total suspended solids mg/l	Phosphate (ortho) as PO_4 mg/l	Tot.Phosphorus µg/l
Boreholes												
RGMBH7	6	Min	181	292	0.03*	19.3	38	0.036**	2.87***	16	-	<100
		Max	210	354	5.22*	23	40.2	0.113**	15.6***	136	-	-
		Average	189	311	2.63*	20.6	39.1	0.07**	7.34***	71	-	-
RGMBH13	7	Min	75	224	0.04*	18.8	50.6	<0.015**	0.85***	33	-	<100
		Max	145	327	0.38*	28.9	88.7	0.66**	8.99***	587	-	-
		Average	95	269	0.21*	22.5	71.3	<0.1	3.2***	206	-	-
*Ammoniacal Nitrogen as NH_3; **Nitrite as N; ***Nitrate as N # refers to the number of samples taken												

Sample ID	no.		Calcium mg/l	Magnesium mg/l	Manganese µg/l	Potassium mg/l	Sodium mg/l	Iron mg/l
Boreholes								
RGMBH7	8	Min	55	11	846	1	26	<0.019
		Max	101	13	1243	1.9	29	1.79
		Average	68	12	1002	1.2	28	0.37
RGMBH13	9	Min	27.5	5.8	3.03	3.2	32	<0.019
		Max	50	8.6	559	4.4	38	0.386
		Average	36	6.9	112	3.7	35	0.17

Major ions have been used to produce Piper plots of water quality for each sampling event (see annex H.3).

The borehole Piper plot is shown in annex H.3; this shows the water in RGMBH13 and RGMBH7 to be of a calcium-bicarbonate type, although this is more so in RGMBH7 than RGMBH13 which has a greater proportion of chloride than RGMBH7. In addition, the manganese concentrations (which do not form part of the Piper plot) in the water in the boreholes are very different, with the concentrations of manganese in RGMBH7 being significantly elevated in comparison to those from RGMBH13. Given the different locations and different responses to rainfall events identified earlier, it is not surprising that the water quality in the two boreholes is different. There are some temporal variations in quality, but overall the time series data show that the water type is broadly consistent through all of the monitoring rounds confirming that the differences are 'real' and not an anomaly associated with the time of sampling. However, RGMBH13 shows slightly more temporal variation in chemistry than RGMBH7.

The Piper plots of the piezometers and surface water within Cae Gwyn SSSI show distinct water types across the different basin areas, and as such have been discussed separately below. A Piper plot has also been created for the piezometers and boreholes to determine any differences/similarities between the bedrock groundwater and the shallow water stored within the peat and mineral soils (see annex H.3). This shows a greater difference between the basins than between bedrock groundwater and peat/soil groundwater.

The Northern and Western Basins show similar major ion chemistry (annex H.3) which is distinctly different from the groundwater as indicated by the boreholes and other basins. The Northern and Western Basin waters are dominantly sodium-chloride type, although sodium and chloride are not elevated at these two locations, it is just that the other major ions have lower concentrations. The piezometers in these basins are not installed in peat and are essentially in shallow mineral soils. The sampled water is therefore not derived from bedrock groundwater and is likely to be indicative of a rainwater origin. Additionally, the surface water features within these areas are also of similar types. The Environment Agency has indicated that most of the sodium in the Anglesey waters appears to be marine-derived rather than from rocks and chloride is not typically a lithologically-derived parameter. The time series data on the Piper plots shows that the water type is consistent through all of the monitoring rounds with the exception of August and October 2016 during which chloride is less dominant.

The Southern Basin Piper plot (annex H.3) does not show a consistent water type, changing throughout the year and between the different sampling locations suggesting that the recharge and flow change through the year. There was no sampling in March, April, June or July and so there are no data plotted for these months.

In November and December 2015, when samples from the Southern Basin were taken from the water surface (sample CG_S) as the piezometers had not been drilled at that time, the water type is similar to the Northern and Western Basins and is a sodium-chloride type. No subsequent samples were taken from this location.

The water samples taken from the surface water flowing into this basin (CG_Road) and out of this basin (CG_SDrain) are of a similar water type when sampled in February 2016, and are similar to the water type from the piezometer suggesting that the water within the basin in February is all from a similar source, and potentially indicating some groundwater input to the Road Drain.

The water samples taken from the Southern Basin piezometer (CG_PZ_S) change quite markedly through the year, particularly with regard to anions, with chloride in particular generally showing a reduction from winter to summer and bicarbonate becomes the more dominant anion. This suggests that rainwater dominates water quality in the peat in the winter, but groundwater, or ionic change due to longer water residence times in the peat, become important in the summer.

The piezometer in the POB displayed a slightly more consistent water type than the Southern Basin for the majority of the year, as shown in annex H.3. From November 2015 until February 2016, the POB piezometer, surface water sample, Outfall Channel and the minor drains across the site show a calcium carbonate dominant water type, although chloride is quite variable. This is a similar to RGMBH13. In April/May and August 2016, however, the water quality within the POB piezometer shifts with the proportion of chloride being much lower. This is the same type as RGMBH7 (see annex H.3) and indicates that there are groundwater inflows to the POB throughout the summer, although the water may be from a different groundwater unit. The water type within the Outfall channel is also calcium carbonate dominated, with a moderate proportion of chloride.

No exceedances of the 2015 EQSs were observed for the substances that were regularly measured at all locations. Manganese was only analysed for a small number of samples, but the results indicate very low concentrations in the groundwater at RGMBH13, but very high concentrations in RGMBH7 and in the outfall on Nant Caerdegog Isaf. This supports the assertion derived from the water level plots that RGMBH7 is potentially in continuity with water in Nant Caerdegog Isaf which is close to the borehole position.

2.7.4 Nutrients

Water samples were scheduled for analysis of macronutrients including nitrates, phosphate and potassium. A summary of the results is included in table D8-6-2-7. Concentrations of nitrates have been screened against a threshold value (TV) of 2mg/l for a healthy wetland as described in the UK Technical Advisory Group [RD15] technical report on GWDTEs threshold values. The concentrations of nitrate across the monitoring locations were dependent upon whether each area was within an area actively farmed. The concentrations of nitrate within the Southern, Western and Northern basins were either below the level of detection or within the TV, with the exception of one sample taken from the Western Drain. Both the Southern and Western Basins are fenced off from surrounding farms and have no direct surface water input from neighbouring agricultural fields. CG_Outfall, CG_ODrain, CG_POB and CG_PZ_POB all had at least one exceedance of the TV. These locations are all within, or immediately downgradient of, fields containing livestock (cattle and sheep).

UKTAG [RD15] reports phosphate concentrations for fens in good condition (0.021mg/l) and in poor condition (0.064mg/l). The majority of sample locations had phosphate concentrations below the value for fens in good condition. The locations exceeding this value, and in the range of a fen in poor condition or above, include CG_Outfall, CG_POB, CG_NPond and CG_PZ_N. The highest concentrations were observed in the Northern Pond in August 2016, when water levels in the pond were very low and when cattle have direct access to it.

A TV for potassium is not currently available. The concentrations of potassium show a similar pattern to the nitrate and phosphate concentrations though, and are highest in the Northern Pond, the POB and the Outfall Drain.

The source of all nutrient enrichment is thought to be agricultural; although nutrient concentrations are generally low and do not appear to impact upon the Southern and Western basins.

2.7.5 Organic analyses

Two samples have been analysed for total petroleum hydrocarbons and volatile organic compounds, but no substances were detected.

3. Conceptual hydrological models

Cae Gwyn SSSI comprises a system of basin mires separated by dry heathland habitat. Based upon the information contained within this report, Cae Gwyn is not a single uniform site, instead it is a site that comprises four basins and a central rocky outcrop. These basins are the Southern Basin, the Northern Basin, the POB and the Western Basin. There are two distinct catchments within the site; the main catchment (0.29km^2) and the western catchment (0.008km^2).

The four basins display different ecological qualities and appear to function in different ways.

- Peat is encountered in only the Southern Basin and the POB.
- The plant communities in each basin differ from one another, indicating different hydrological supporting conditions.
- All water samples collected in and around Cae Gwyn are characterised by a neutral to acidic pH, reflecting the SSSI citation description of an acid wetland, as well as overall low concentrations of total dissolved solids and nutrients. A distinct difference in hydrochemistry exists between the Northern and Western basins and the Southern Basin and POB, indicating that they operate under different hydrological regimes.

Based upon this, the conceptual site model for Cae Gwyn has been separated into a description of each basin, as summarised below relating to the ecology, water level, surface water flow and water balance, and the water quality data. A synthesis of this information is made in Section 3.5, describing the extent to which the basins interact and fit within the wider landscape.

3.1 Southern Basin

The Southern Basin is a bog or poor fen, with its surface at an elevation of approximately 28mAOD. The key features of this basin are outlined below.

- **Soil** – The basin is underlain by peat which has thickness in excess of 1.4m.
- **Ecology** – The basin comprises a central area of bog or poor fen surrounded by a diversity of transition mire communities and wet heath. The plant communities present on the surface of the basin do not indicate that this surface is entirely ombrogenous and it is expected that there is contact between the plants on the surface of the mire with the water regime in the underlying peat basin, including perhaps the movement of groundwater through it. There is a very small area of M14 within the basin which suggests groundwater inflow could be important, but only in a very small area.
- **Surface water flows and features** – The basin receives surface water inflows from the surrounding catchment and a small drain. The basin outflows via the Southern Drain to the POB; access issues prevented flows within these watercourses being monitored. There is a small pond located to the south of the basin.
- **Peat water levels** – Water levels in the peat remained at, or just above, ground level between January and March 2016, before declining in the summer months and then rising back to near surface level in early autumn. The maximum variation in water levels in the peat was 0.3m throughout the year, significantly less than the 4m variation seen in the bedrock groundwater levels recorded by RGMBH13, installed upgradient of the basin. Given that water levels recorded by the piezometers remain relatively high throughout the summer, when bedrock groundwater levels drop beneath the base of the peat, it is likely that the peat manages to retain water, or the basin does not freely drain into the bedrock. A possible explanation is the potential for glacial till to be present beneath the peat. A 0.2m to 0.4m layer of glacial till was identified in the core taken from RGMBH13, although there is no data that indicates whether till is present beneath the Southern Basin.
- **Water balance** – The water balance for the Southern Basin has a number of uncertainties, as neither the inflow nor the outflow channels were monitored and flows have been assumed to be proportional to flows along Nant Caerdegog Isaf. During winter, spring and autumn the inflows to the basin were greater than outflows, potentially due to uncertainties, or possibly some groundwater recharge. The 2016 summer months generally had greater outflows than inflows, but with little change in the water level within the

basin. In the autumn the basin wetted up with water levels increasing and higher inflows than outflows. Overall the water balance for 2016 indicated that inflows were 134% of outflows suggesting that there could be groundwater recharge from the basin.

- **Water quality** – Piper plots show that the water quality in the Southern Basin from November to January was a sodium-chloride type indicating rainwater inflows. Throughout the spring/summer months surface water and piezometers shifted to show no dominant type, which is similar to borehole RGMBH13, indicating that there may be some groundwater inflows into the basin. In August, the chloride dropped markedly and bicarbonate became the dominant anion, which is indicative of very low flow within the basin. The comparatively high electrical conductivity readings from the piezometers in the Southern Basin suggest that there is a degree of mineral enrichment of water compared to the other basins. This is reflected by the slightly elevated concentrations of total dissolved solids, calcium, total alkalinity as $CaCO_3$, sulphate and manganese. Measurements of pH and electrical conductivity are not so low as to suggest a purely rain-fed basin.

Based upon the 2016 water balance, it appears that the majority of inflows to the basin are due to surface water inputs, including direct rainfall, inflow from the catchment and from the Road Drain. The water balance may indicate some infiltration to groundwater. The Road Drain may incorporate some groundwater inflow as well as road runoff, but groundwater is unlikely to be a key supporting feature. The groundwater levels, water quality and ecology indicate that there is some groundwater enrichment of the basin, potentially from seepages around the edge of the basin. Based upon the lines of evidence it is concluded that this basin is generally surface water fed, with limited potential for groundwater inflows.

3.2 Northern Basin

The Northern Basin is an acid area of open water with a fluctuating water level and associated aquatic/semi-aquatic and transitional plant communities. The basin includes a pond (Northern Pond). The surface is at an elevation of approximately 24.5mAOD. The key features of this basin are outlined below.

- **Soil** – The basin is underlain by mineral soils to a depth of 0.3mbgl.
- **Ecology** – The main plant communities of interest are found in more-or-less permanently wet areas of seepage or flow of acid waters, or at the margins and in the shallows of acid waterbodies, such as ponds, with a seasonal variation in water level. Water can be supplied in a variety of ways but is oligotrophic and acidic.
- **Surface water flow** – The basin receives flows from the small surrounding surface water catchment, with no formal inflow channel; additionally there is no formal outflow channel from the basin. The Northern Basin is separated from the POB by a shallow rocky outcrop with a maximum elevation of 25.7mAOD; therefore any rise in water above this elevation would result in discharge informally towards the POB.
- **Basin water levels** – Water levels within the Northern Basin dropped from January to June 2016. From November to October, the Northern Basin showed signs of recovery following the summer/autumn decline in water level, with water levels returning to the ground surface in December 2016.
- **Water balance** – The water balance shows that for 2016 inflows are substantially greater than outflows for the Northern Basin, especially during the winter months. This indicates that there were likely losses from the basin via an informal overland flow route and losses to groundwater. It is likely that during winter some of the losses are overland, with overflow occurring once water reaches 25.7mAOD. During the summer months inflows and outflows are in balance.
- **Water quality** – Piper plots show that the Northern Basin contains waters of predominantly sodium-chloride type similar to surface water features, suggesting that the basin is isolated from groundwater input throughout the year and that recharge is via direct rainfall or surface water runoff. Nutrients are elevated in this basin, especially the Northern Pond, likely due to inputs from cattle which can access the basin.

Based upon the above observations, it appears that the Northern Basin receives flows purely from rainfall to the basin and catchment with no groundwater input. The water balance and observations suggest that rainfall discharges from the basin via an overland flow route and through seepage to bedrock, indicating that this basin results in recharge of groundwater below the site.

3.3 Primary Outflow Basin

The POB is a large and flat basin with a surface elevation of approximately 23mAOD, generally sloping down to the north-east towards the outfall channel, Nant Caerdegog Isaf, at 22.2mAOD. The north of the basin incorporates some minor field drains which cross the basin; these were likely dug to drain the adjacent field. The key features of this basin are outlined below.

- **Soil** – The basin is underlain by a silty peat that is in excess of 1.8m thick.
- **Ecology** – The POB supports a closed community of herbaceous plants dominated by grasses and rushes with a large central block of willow carr. The dominant plant communities are supported by moderately base-rich conditions and are tolerant of waterlogging, but their soils tend to dry out in summer. There can therefore be a strong seasonal variation in water table in the peat without significantly affecting the plant communities. Smaller units of vegetation within the basin indicate wetter, more mineral-rich conditions. There is a very small area of M13 within the basin which suggests groundwater inflow could be locally important.
- **Surface water flow** – the basin receives inflows from direct rainfall, rainfall to the catchment, along with inflows from the Southern Drain, and also potentially some overflow from the Northern Basin during the winter. The POB is drained by Nant Caerdegog Isaf; flows along this watercourse were highest in late winter and early spring (December 2015 to March 2016) and lowest in late summer and autumn. The results of flow and water level monitoring along Nant Caerdegog Isaf 800m downstream of the SSSI suggest that during the summer months rainfall is retained in the upper catchment, but during the winter there is a groundwater input to the watercourse.
- **Peat water levels** – Water levels in the peat remained at or just above ground level between January and March 2016 and then declined more rapidly than in the Southern Basin throughout the spring/summer months, when flows in the Nant Caerdegog Isaf also reduced. Water levels then rose back to near surface level in early autumn. The maximum variation in water levels in the peat, throughout the year, was 0.7m, slightly more than the 0.5m maximum variation observed in the nearby RGMBH7, installed in the bedrock. These levels indicate that the water levels in the peat are in partial hydraulic continuity with the bedrock groundwater levels within the POB, and that during summer, when the bedrock water table drops to, or below the base of the peat, water levels in the peat drop fairly rapidly and flows within Nant Caerdegog Isaf also decrease as a result of a reduction in baseflow. The absence of till recorded in the core from RGMBH7 could indicate that till is also absent at the location of the POB piezometer, although there is significant uncertainty associated with this. Should bedrock groundwater levels drop below the base of the peat, it is possible for the peat to drain to the underlying bedrock during summer.
- **Water balance** – The POB water balance indicates that at a catchment scale, the inflows and outflows are broadly in balance over the year, but with a strong seasonality with outflows being much greater than inflows during the summer suggesting that the POB is drying at this time. This is corroborated by the water level data from the piezometer. It is likely that during the summer months the water stored within the basin drained to Nant Caerdegog Isaf which was lower than the water level in the peat, or seeps to groundwater. The water balance for the catchment as a whole does not suggest significant groundwater exchanges in this basin, although individual groundwater seepages not picked up by the bulk water movement calculations may occur at a local level.
- **Water quality** – Piper plots indicate that water samples taken from in and around the POB were of no dominant type in the winter months, suggesting some groundwater inflow. In May and August 2016, the water quality in the piezometer samples shifts towards a calcium-bicarbonate type, indicating slow flow within the basin. The comparatively high electrical conductivity readings from the piezometers in the POB suggest that there has been a degree of mineral enrichment of water in the peat compared to the other basins. This is reflected by the slightly elevated concentrations of total dissolved solids, calcium, sulphate, manganese and total alkalinity. Elevated concentrations of nitrates, potassium and phosphates, exceeding TVs, have been recorded in the POB; the source of these nutrients is thought to be agricultural including cattle and sheep access to the basin.

Based upon the water balance, it appears that the vast majority of the water within this basin is from surface water sources. The water levels show that the groundwater intersects the POB during the winter months, which is supported by the water quality and ecological assessment of the basin. During the summer months the basin may result in some limited recharge to groundwater.

3.4 Western Basin

The Western Basin is a small area of relatively flat wet grassland with a depression in the centre and has a ground elevation of approximately 25mAOD. The basin is not within the same catchment as the rest of the SSSI and is separated from the other basins by a rocky outcrop with an elevation of 26.4mAOD. The key features of this basin are outlined below.

- **Soil** – The basin is underlain by mineral soils to a depth of 0.4mbgl.
- **Ecology** – The Western Basin is an area of wet, acid grassland with surrounding wet heath communities that likely dry out in the summer.
- **Surface water flow** – There is no formal drain or outflow from the Western Basin; however once water reaches a certain elevation it is likely to flow overland to the Western Drain. The Western Drain flows to a minor tributary of the Afon Cafnan, which discharges to the Afon Cafnan upstream of Nant Caerdegog Isaf.
- **Basin water levels** – Water levels in the soil in the Western Basin remained near the surface from winter until May 2016, when water levels dropped quickly to the base of the soil. Water levels then began to recover in September, and returned to ground level in November 2016.
- **Water balance** – The Western Basin water balance shows a significant imbalance with inflows estimated as 289% of outflows for the whole monitoring period suggesting that there are flows that have not been incorporated into the calculations. In the summer months the basin is more or less in balance, however, water levels declined, suggesting that there could be seepage to the underlying bedrock. The water levels in the basin increased in September 2016 which coincided with greater inflows. The water balance suggests significant unmonitored overland flow to the Western Basin during autumn, winter and early spring.
- **Water quality** – Piper plots produced show that the Western Basin contains waters of predominantly sodium-chloride type, which indicates that the basin receives water from rainfall and is isolated from groundwater. The Western Basin has no elevated concentrations of nutrients.

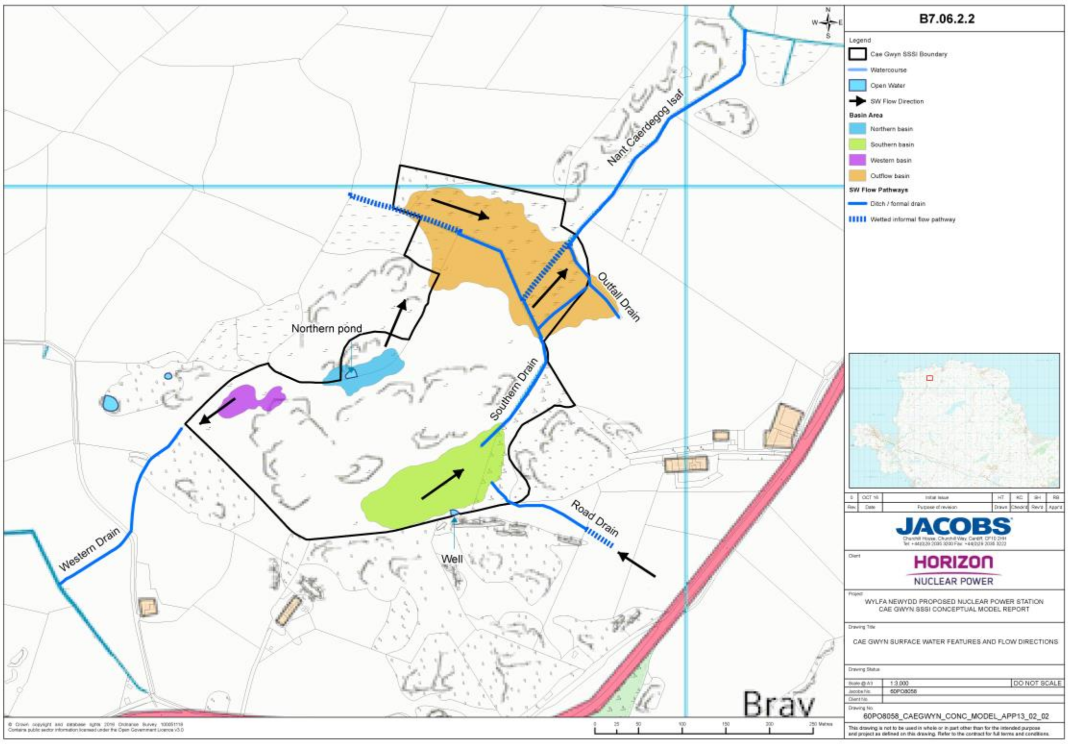
The Western Basin, although different in ecological character to the Northern Basin, appears to have a similar hydrological function. Based upon the above observations the Western Basin receives flows purely from rainfall to the catchment and the basin with no groundwater input. The water balance and water level suggest that rainfall discharges from the basin by overland flow to the Western Drain during winter and through seepage to bedrock in summer.

4. Hydroecological supporting conditions and assessment of sensitivity to change

The habitats at Cae Gwyn SSSI are an expression of the prevailing environmental conditions including water supply mechanism and water quality. Vegetation surveys of the site [RD5] have found a diversity of plant communities, and these indicate a corresponding range of supporting hydrogeological conditions, e.g. plant communities of acid pools with variable water level and also communities of acid to more basic flushes. The composition of plant communities, diversity of species and the structure of the wetland system all suggest long continuity of both these ecological features and their supporting conditions.

As identified in Section 1, a fundamental objective of this investigation is to ascertain the dependence of wetland vegetation at Cae Gwyn SSSI on the prevailing groundwater and surface water conditions. This section summarises the baseline conditions with respect to flows, levels and quality for each hydro-ecological unit, i.e. each basin, and relates these to the plant communities each unit supports. The sensitivity to changes in water level and water quality of each unit and certain plant communities within them is also assessed and described. This section therefore sets out the conditions that need to be present and maintained to ensure that the ecological condition of Cae Gwyn SSSI does not deteriorate.

4.1 Southern Basin

<table>
<tr><th colspan="5">HYDROECOLOGICAL BASELINE</th></tr>
<tr><td>MAP</td><td colspan="4">
</td></tr>
<tr><td>SOILS</td><td colspan="4">Peat deposits are proven within the basin to a depth of over 7m. Peat comprised sphagnum at the basin surface. Mineral soils were found along the edges of the basin.</td></tr>
<tr><td rowspan="2">FLOW</td><td rowspan="2">Receives inflows from direct rainfall, the surrounding catchment and a small drain (Road Drain). The basin discharges via the Southern Drain.
The drains were observed to be flowing during late autumn and winter months, but were not monitored</td><td></td><td>MIN</td><td>MAX</td></tr>
<tr><td>SOUTHERN DRAIN (VISUAL ESTIMATE IN WINTER)</td><td>0.3l/s (likely to be 0l/s in summer)</td><td>16l/s</td></tr>
</table>

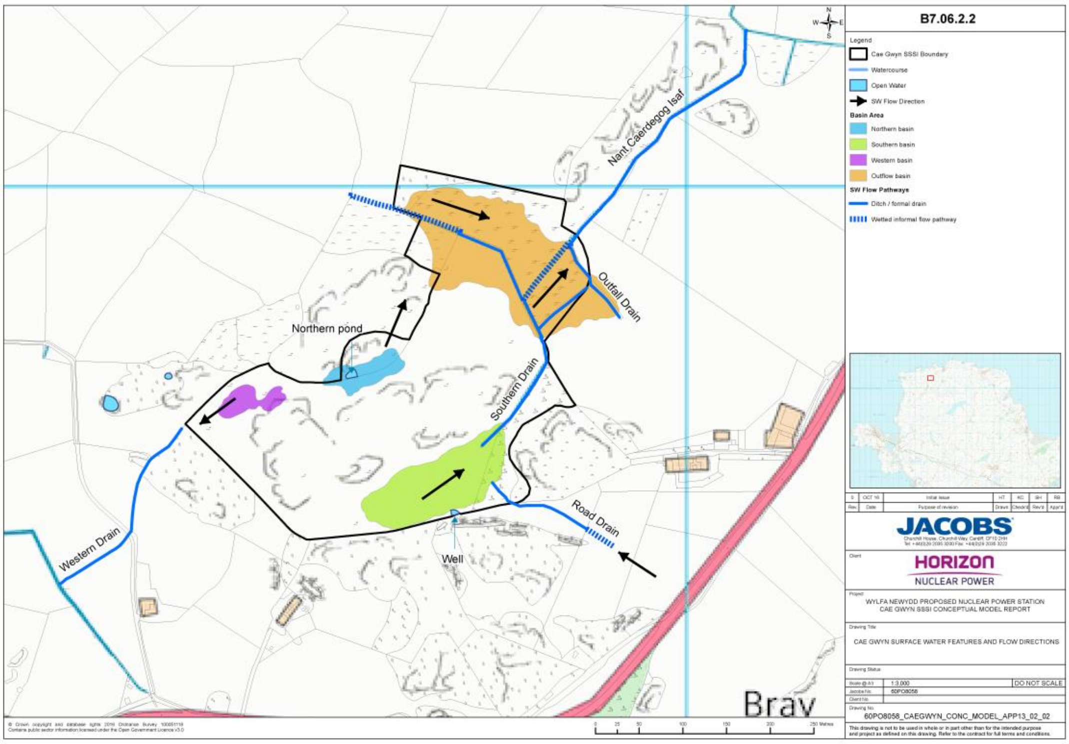
Hydroecological Baseline				
	for flows due to access issues; therefore flows are visual estimates. The drains were not observed during the summer months.	**Road Drain (visual estimate in winter)**	0.2l/s (likely to be 0l/s in summer)	7.5l/s
Water Levels	The maximum variation in water levels in the peat is 0.3m throughout the year and is lowest in summer and autumn.	**CG_PZ_S**	27.6mAOD	27.9mAOD
		RGMBH13	27.1mAOD	30.7mAOD
Water Balance	Poor balance between inflow and outflow (134%) with likely infiltration to groundwater, but high uncertainty due to limited flow data.	For available data: Estimated inflows = 45,447m^3 Estimated outflows = 33,940m^3		

Water Quality	**Southern basin piezometer**			**Southern and Road Drain**			**Well and basin surface**		
	Min	**Max**	**Avg**	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**
pH	5.0	6.6	6.1	5.3	8.0	6.6	5.5	7.8	6.2
EC (µS/cm)	235	496	381	186	396	281	66	217	179
Nitrate as N (mg/l)	<0.07	<0.07	<0.07	<0.07	1.1	0.36	<0.07	<0.07	<0.07
Potassium (mg/l)	<1	<1	<1	<1	1.1	1.1	<1	2.7	1.79
Phosphate as P (mg/l)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Calcium (mg/l)	14.2	30.0	25.3	6.3	43.9	27.0	6.1	19.5	9.9
Alkalinity (mg/l)	28	110	82	5	110	66	5	20	14

Water supply mechanism	The inflows to the basin come from direct rainfall, runoff from the immediate surrounding catchment and from a drain which receives flows from the road and potentially a spring source. Based upon the water quality and water levels it is also likely that there is some limited direct or spring-fed groundwater inflow to the basin.
Ecology	The Southern Basin comprises a central area of mire dominated by the non-NVC community M15 *Scirpus cespitosus-Erica tetralix* wet heath 'swampy variant'. This is surrounded by a diversity of transition mire communities and wet heath. The mire is supported by water permanently above or at the surface (water levels in the peat vary by only about 0.3m throughout the year) and has a quaking surface. M15 'swampy variant' is understood in Wales to represent a stage mid-way in the succession of topogenous poor-fen vegetation to raised ombrogenous (rainwater-fed) bog [RD12]. The surface of the mire was observed to be slightly raised, but the plant communities present and the hydrological understanding of the basin do not indicate that this surface is entirely ombrogenous: measurements of pH and electrical conductivity are not so low as to suggest a purely rain-fed surface. It is expected therefore that there is contact between the plants on the surface of the mire with the water regime in the underlying peat basin, including perhaps the movement of groundwater through it. The main peripheral mire communities are M5 *Carex rostrata-Sphagnum squarrosum* mire and S27 *Carex rostrata-Potentilla palustris* tall-herb fen, which are amongst the most frequent transition mire communities in Welsh bogs [RD12]. These are typical of shallower peat profiles or mineral soil and are indicative of a high water level and moderate base-enrichment of the water supply and/or substrate. The origin of the more base-enriched waters supplying largely topogenous communities may be groundwater; given the groundwater levels in the bedrock these waters most likely would derive from localised perched flushes peripheral to the central mire. The existence and nature of such flushes was not investigated. Also peripheral to the main area of mire are less extensive areas of M14 *Schoenus nigricans-Narthecium ossifragum* mire and M16 *Erica tetralix-Sphagnum compactum*. M14 is indicative of some slight mineral enrichment and a groundwater influence, but only in a very small part of the Southern Basin. M16 is found over both peat and mineral soils, and can withstand strong drawing-down of the water table, typically drying out in the summer.

Sensitivity to Change	
Sensitivity to change in water quantity	The plant communities within the Southern Basin are supported by very wet conditions and are therefore potentially very sensitive to a decrease in the quantity of water supplied. NRW has reported that the site is in unfavourable condition due to encroachment of scrub on the site, and wet woodland is developing on the eastern edge of the Southern Basin. The central area of very wet deeper peat is more resistant to colonisation by shrubs and trees, but a drawing-down of the water level would make this area more readily colonisable. Drainage would lead to other changes in community composition: a lowering of the water table and greater aeration of the soil would favour the growth of purple moor-grass (*Molinia caerulea*), for instance, and this would out-compete the smaller herbs and the bryophytes within the bog / poor fen. As the Southern Basin is understood to be predominantly surface and rainwater fed, at the catchment scale, any changes in the surface water drainage of the basin are likely to have a significant adverse impact on the integrity of the vegetation. Water levels in the peat do not appear to significantly reduce in the summer months and the peat may be prevented from freely draining into the underlying aquifer, possibly due to the presence of glacial till and an elevated groundwater table. Based on this conceptual understanding a drawdown in bedrock groundwater would be unlikely to have a significant effect on the basin as a whole, although as the basin may be fed by individual groundwater seeps, it is potentially sensitive to changes in groundwater supply at the local level, which are important in mainting critical assemplages. However, as discussed previously, without boreholes within Cae Gwyn there are considerable uncertainties associated with this.
Sensitivity to change in water quality	The vegetation of the Southern Basin is supported by mildly acid, moderately mineral-rich and nutrient-poor conditions. Changes in any of these parameters are likely to adversely affect the integrity of the vegetation. Eutrophication is more likely to occur than other changes in water/soil chemistry and would also have the most significant effect. Excessive nutrient input would manifest in an increase in more competitive species, especially monocots, and a consequent decline in site condition. The basin is additionally vulnerable from eutrophication as there is some access for livestock which might crop excessive growth. Eutrophication is most likely to result from intensive agricultural activity within the surface water catchment, or pollution of the road drain to the south-east. Groundwater contamination would likely have a less significant effect given the water supply mechanism to the basin.

4.2 Northern Basin

Hydroecological Baseline	
Map	
Soils	No peat was encountered within the Northern Basin. Mineral soils were proven to a depth of at least 0.26m; these soils had a significant volume of plants and roots within them.
Flow	No flow routes were observed during any site walkover. During the winter the ground was very wet between the Northern Basin and POB, however no flow was observed.
Water Levels	The water levels within the piezometer have a maximum range of 0.3m; this is limited by the thin soils.
Water Balance	Assumed inflows significantly exceed assumed outflows (by 380%), which suggests additional outflows that could include leakage to groundwater and/or informal overland flow. For available data: Estimated inflows = 5,517m^3; Estimated outflows = 1,452m^3

Water Levels

	Min	Max
CG_PZ_N	25.4mAOD	25.7mAOD

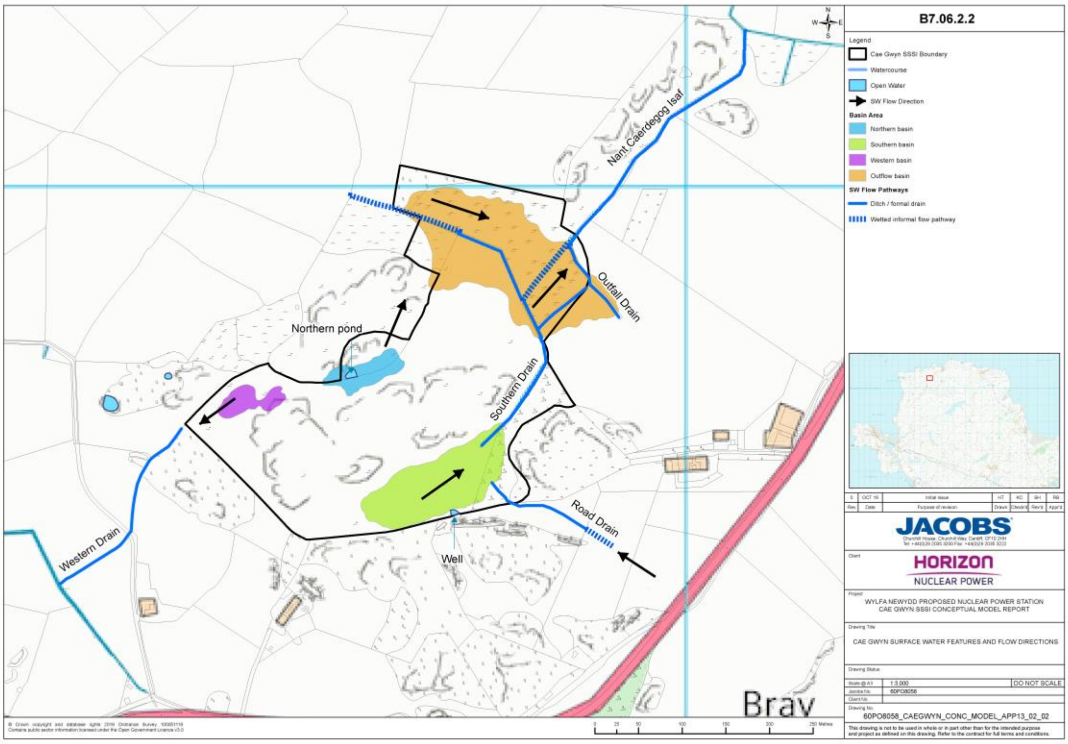
Water Quality

Water Quality	Northern Basin Piezometer			Northern pond		
	Min	Max	Avg	Min	Max	Avg
pH	6.0	7.0	6.5	5.6	7.7	6.6
EC (µS/cm)	160	391	256	126	483	224
Nitrate as N (mg/l)	<0.07	0.2	0.1	<0.07	0.7	0.27
Potassium (mg/l)	<1	3.5	2.3	2.0	43.2	17.5
Phosphate as P (mg/l)	<0.02	0.23	0.06	<0.02	2.2	0.6
Calcium (mg/l)	3.5	11.8	6.0	3.7	12.2	7.7
Alkalinity (mg/l)	7	15.5	11	4.5	135	45

Hydroecological Baseline	
Water supply mechanism	The majority of water flowing into this basin is thought to be from direct rainfall and inflows from the small surrounding catchment. It is likely that water infiltrates from this basin to bedrock, and potentially overflows to the POB.
Ecology	The Northern Basin is an acidic pond with fluctuating water level. The main plant communities recorded are M29 *Hypericum elodes-Potamogeton polygonifolius* soakway and M30 Related vegetation of seasonally-inundated habitats. M29 is found in more-or-less permanently wet areas of seepage or flow of acid waters and consists of floating plants able to rise and fall with water levels. M30 is an ill-defined unit consisting of aquatic or semi-aquatic plants associated with the margins and shallow water of acid waterbodies, such as ponds, with a seasonal variation in water level. The two communities are closely related, and water can be supplied in a variety of ways but should be oligotrophic.

Sensitivity to Change	
Sensitivity to change in water quantity	As it supports essentially aquatic communities the Northern Basin is sensitive to a reduction in water supply. Much of the open-water vegetation present in the basin (e.g. bog pondweed, *Potamogeton polygonifolius*) is able to rise and fall with the water level and so is to some extent able to withstand a partial lowering of the water levels in pond areas. Lowering of water levels will affect the less mobile species occupying the seasonally inundated margin of the basin. As the basin is unlikely to be groundwater-fed, only modifications to surface drainage or a significant reduction in rainfall will adversely affect water supply to the basin. In addition to evapotranspiration, the basin is thought to lose water to bedrock by vertical infiltration.
Sensitivity to change in water quality	Trophic status is a key determinant of the ecology of ponds, and the plant communities found within the Northern Basin are indicative of nutrient-poor and acid conditions. As a surface-water fed feature therefore the Northern Basin is sensitive to nutrient enrichment in its catchment. Given the surrounding land use this is most likely to result from agriculture.

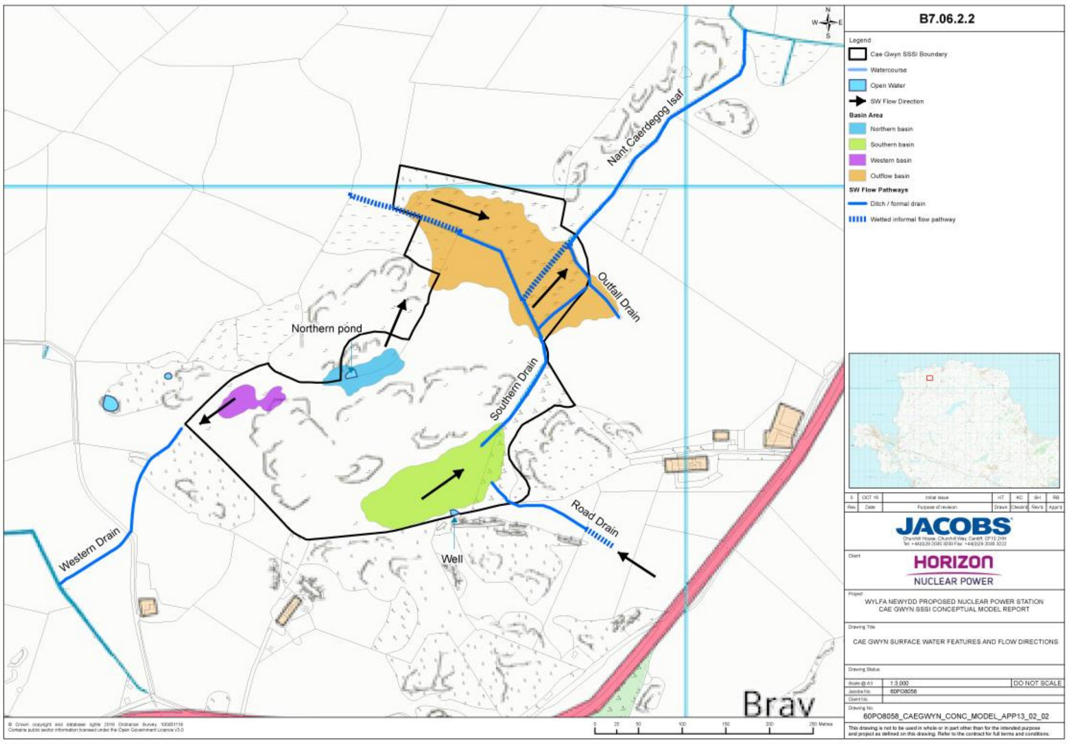
4.3 Primary Outflow Basin

<table>
<tr><th colspan="5">PRIMARY OUTFLOW BASIN HYDROECOLOGICAL BASELINE</th></tr>
<tr><td>MAP</td><td colspan="4">
</td></tr>
<tr><td>SOILS</td><td colspan="4">Peat deposits are proven within the basin to a depth of at least 1.8m, although it could be much thicker in the centre of the SSSI. Where sampled, the peat comprised a silty peat through the full depth of core. Mineral soils were found along the edges of the basin.</td></tr>
<tr><td rowspan="4">FLOW</td><td colspan="4">The POB appears to predominantly receive flows from direct rainfall, rainfall to the surrounding catchment, and inflows from the Southern Basin via the Southern Drain. This basin may also receive some overland flows from the Northern Basin. The Southern Drain was observed to be flowing constantly in the winter months, with high variation in flows; very high flow rates occurring immediately after rainfall. The Southern Drain was not observed in the summer months; therefore it is not known whether this drain flows year-round.</td></tr>
<tr><td rowspan="3">The POB discharges via Nant Caerdegog Isaf which is highly incised. The channel is wetted year-round. It was not possible to monitor due to being overly deep and wide and any flow was visually imperceptible. Nant Caerdegog Isaf was observed to flow year-round 800m downstream of the site, with high variation throughout the year and especially following storm events.</td><td></td><td>MIN</td><td>MAX</td></tr>
<tr><td>SOUTHERN DRAIN (WINTER VISUAL ESTIMATES)</td><td>0.3l/s (likely to be 0l/s in summer)</td><td>16l/s</td></tr>
<tr><td>NANT CAERDEGOG ISAF (800M DS / JAN 2016 – FEB 2017)</td><td>0.07l/s</td><td>112l/s</td></tr>
<tr><td rowspan="3">WATER LEVELS</td><td rowspan="3">The change in water level within the piezometers is 0.7m throughout the year, and is lowest during the summer and autumn.</td><td>CG_PZ_POB</td><td>22.3mAOD</td><td>23.0mAOD</td></tr>
<tr><td>RGMBH7</td><td>22.4mAOD</td><td>23.0mAOD</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>WATER BALANCE</td><td>Based on the available information inflows are estimated to be just less than outflows (96%) and on a catchment scale, it is unlikely that the basin is supported by significant groundwater inflows, although individual groundwater seepages may be crucial for maintaining certain important species.</td><td colspan="3">For available data:
Estimated inflows = 81,865m^3
Estimated outflows =85,516m^3</td></tr>
</table>

Primary Outflow Basin Hydroecological Baseline									
Water Quality	**POB piezometer**			**POB SW & Outfall Drain**			**Nant Caerdegog Isaf**		
	Min	**Max**	**Avg**	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**
pH	5.4	7.7	6.7	6.7	7.1	6.9	5.9	7.8	6.7
EC (µS/cm)	73	640	428	227	758	347	238	570	345
Nitrate as N (mg/l)	<0.07	2.6	0.5	<0.07	4.6	1.8	0.27	0.76	0.45
Potassium (mg/l)	<1	9.2	3.9	2.3	4.8	3.2	1.1	5.4	3.1
Phosphate as P (mg/l)	<0.02	<0.02	<0.02	<0.02	0.08	<0.06	<0.02	0.04	<0.02
Calcium (mg/l)	20.3	83.0	60.5	25.4	66.0	33.6	25.4	48.0	38.8
Alkalinity (mg/l)	55	275	190	55	215	101	70	155	116
Water supply mechanism	The inflows to the basin are thought to come from a number of sources including direct rainfall, runoff from the surrounding catchment and flows along the Southern Drain. It is unlikely that there are proportionally large groundwater inflows into the basin at the catchment scale, but given the water quality data and presence of certain species, limited groundwater inputs may be critical at the local level.								
Ecology	The POB supports a closed community of herbaceous plants dominated by grasses and rushes. It is thought that this basin represents a quaking bog that has been artificially drained by the Nant Caerdegog Isaf. The main plant communities are: (i) overlying peat soils, M24 *Molinia caerulea-Cirsium dissectum* fen meadow and, (ii) overlying mineral soil, M23 *Juncus effuses/acutiflorus -Galium palustre* rush pasture. While tolerant of waterlogging, soils supporting M24 tend to dry out in summer, and this increased aeration favours the growth of the dominant grass, purple moor-grass. This is consistent with piezometer data which indicates a strong seasonal variation in water levels in the peat. This community is also supported by moderately base-rich conditions, again consistent with measured field parameters: water samples from the POB have much higher total alkalinity and dissolved calcium than the other basins. Indeed, the area of M24 supports within it a very small community of M13 *Schoenus nigricans-Juncus subnodulosus* mire, a community often found in highly calcareous conditions, fed by groundwater and usually with water at or above the surface for most of the year. This potentially suggests local importance of groundwater in the POB. The area around the Nant Caerdegog Isaf supports the rush-dominated M23. This is suggestive of year-round water-logging of the soil and/or some seepage above the stream, perhaps corresponding to a lower ground level.								

Sensitivity to Change	
Sensitivity to change in water quantity	The results of this study suggest that the peat-filled part of the basin probably represents a drained bog. While the existing water supply is sufficient to re-wet the peat during the winter, further drainage may lead to permanent drying-out of the peat. The consequent shrinkage of peat may be sufficient to lower the surface and mitigate the effects of drying out to some extent, but the vegetation is likely to change toward a drier grassland type. As the basin is fed by both surface and groundwater sources, it is potentially sensitive to changes in either supply mechanism.
Sensitivity to change in water quality	The vegetation of the peat-filled area of the basin is supported by alkaline and mineral-rich conditions. The concentration of nitrate measured in the basin is above the recommended Threshold Value for the habitat. This is likely due to fouling by grazing stock, although the location of the piezometer may not be representative of the whole basin as much of the POB has been scarecely grazed in recent years. The presence of animals to remove any excess growth may mitigate the enhanced nitrate concentrations. Further eutrophication, e.g. by agricultural improvement of the catchment, may not be controllable by this means.

4.4 Western Basin

<table>
<tr><th colspan="7">Western Basin Hydroecological Baseline</th></tr>
<tr><td>Map</td><td colspan="6">
</td></tr>
<tr><td>Soils</td><td colspan="6">No peat was encountered within the Western Basin. Mineral soils were proven to a depth of at least 0.4m; these soils had significant volumes of plants and roots within the upper 0.3m.</td></tr>
<tr><td>Flow</td><td colspan="6">No flow routes were observed during any site walkover, although the basin may drain informally to the Western Drain.</td></tr>
<tr><td rowspan="3">Water Levels</td><td colspan="3" rowspan="3">Based on the available information the water levels within the piezometer have a maximum range of 0.4m, which is likely limited by the small depth of soil.</td><td></td><th>Min</th><th>Max</th></tr>
<tr><th>CG_PZ_W</th><td>24.3mAOD</td><td>24.7mAOD</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>Water Balance</td><td colspan="3">Based on limited data it is estimated that inflows significantly exceed outflows (by about 289%), suggesting leakage to groundwater and/or informal overland flow.</td><td colspan="3">For available data:
Estimated inflows = 2,988m^3
Estimated outflows = 1,032m^3</td></tr>
<tr><td rowspan="2">Water Quality</td><th colspan="3">Western Basin piezometer</th><th colspan="3">Western Drain</th></tr>
<tr><th>Min</th><th>Max</th><th>Avg</th><th>Min</th><th>Max</th><th>Avg</th></tr>
<tr><td>pH</td><td>5.0</td><td>7.4</td><td>6.2</td><td>5.0</td><td>6.8</td><td>6.2</td></tr>
<tr><td>EC (µS/cm)</td><td>112</td><td>314</td><td>205</td><td>117</td><td>355</td><td>293</td></tr>
<tr><td>Nitrate as N (mg/l)</td><td><0.07</td><td><0.3</td><td>0.2</td><td>0.4</td><td>4.4</td><td>3.7</td></tr>
<tr><td>Potassium (mg/l)</td><td><1</td><td>1.4</td><td>1.1</td><td>4.4</td><td>30.4</td><td>17.4</td></tr>
<tr><td>Phosphate as P (mg/l)</td><td><0.02</td><td><0.02</td><td><0.02</td><td><0.02</td><td>0.03</td><td><0.02</td></tr>
<tr><td>Calcium (mg/l)</td><td>2.0</td><td>5.0</td><td>3.4</td><td>5.3</td><td>25.4</td><td>12.3</td></tr>
</table>

Western Basin Hydroecological Baseline						
Alkalinity (mg/l)	2	8	5.5	7.5	55	25
Water supply mechanism	The water flows into this basin from direct rainfall and inflows from the small surrounding catchment. It is likely that groundwater soaks from this basin to bedrock, and surface water potentially overflows to the Western Drain.					
Ecology	The Western Basin is a small area of wet grassland, a mix of the non-NVC community *Agrostis canina-Carex* spp. grassland and M25 *Molinia caerulea-Potentilla erecta* mire. There are also small peripheral areas of M16 *Erica tetralix-Sphagnum compactum* wet heath.					

Sensitivity to Change	
Sensitivity to change in water quantity	As the basin is unlikely to be groundwater-fed, only modifications to surface drainage or a significant reduction in rainfall will adversely affect water supply to the basin. In addition to evapotranspiration the basin is thought to lose water to bedrock by vertical infiltration.
Sensitivity to change in water quality	As a surface-water fed feature, the Western Basin is sensitive to nutrient enrichment in its catchment. Given the surrounding land use, if it does occur, it is most likely to result from agricultural sources.

5. Conclusions

Cae Gwyn SSSI comprises four discrete basin areas, separated by a central rocky outcrop. Connectivity between the basins is limited, with the exception of the Southern Drain, within which surface water flows from the Southern Basin into the POB.

The Northern and Western Basins, although characterised by different plant communities, appear to function in a similar hydrological manner based on the available information. At a catchment scale water balance, neither basin appears to be supported by substantial groundwater inputs. Direct rainfall and surface water runoff from the surrounding catchments appears to provide the only bulk inflows into the basins and significant losses in the summer/autumn months are unlikely, as the water levels measured to date in the two piezometers do not show any significant variations over the course of the year. The losses that do occur are likely to comprise minor overland flows via an informal flow route from the Northern Basin and gradual seepage into the underlying aquifer. As both basins are not supported by substantial groundwater inflows, only changes to the surface water regime, i.e. modifications to existing drainage features, or future changes to the volume of water generated in the surface water catchments, could result in potential future adverse effects to the aquatic and terrestrial communities in the two basins. As surface-water dominated features, both the Northern and Western basins are considered to be sensitive to nutrient enrichment, the main source of which would most likely occur as a result of agricultural practices in the surrounding catchment.

Bedrock groundwater levels are likely intersect the base of the peat in the Southern Basin, although similar to the Northern and Western basins, the Southern Basin is not considered to be supported by groundwater at the catchment scale. Instead, groundwater is considered to play a different role, in that elevated groundwater levels, in comparison to the probable depths of peat in the centre of the basin, are likely to be preventing the free drainage of water stored within the peat into the underlying bedrock. The result is a very low annual fluctuation in water levels in the peat. The groundwater levels, water quality and ecology indicate that there is some groundwater enrichment of the basin, potentially from seepages around the edge of the basin. Based upon these lines of evidence, it is considered that this basin is generally surface water fed, with limited groundwater inflows.

The POB appears to be predominantly surface-water fed with inflows more or less equal to outflows over the monitoring period, albeit with significant seasonal variations. During winter, it is possible that there are elevated bedrock groundwater levels beneath the POB and these could potentially provide an inflow of groundwater into the basin although this is not thought to be substantial in terms of volume at the catchment scale. During winter, when the groundwater table is at its most elevated position, the water level in the piezometer in the peat appears to remain at or close to ground level. In the summer months, water levels in the peat fall. Water quality data and the ecology indicate that the basin is fed by both surface and groundwater sources and is potentially sensitive to changes in either supply mechanism.

Whilst the assessment presented in this report is based on multiple lines of evidence and is considered sufficiently robust to support the Environmental Impact Assessment, there are a number of limitations associated with the data, including:

- data collection is limited to a period of less than two years and is skewed towards the winter months;
- no boreholes extending into the bedrock are present within the SSSI and information on bedrock composition and groundwater levels is inferred from boreholes outside of the site and which penetrate different (albeit hydrogeologically similar) geological strata; and
- peat surveys are limited in extent and depth with instrumentation within the peat limited to one piezometer per basin.

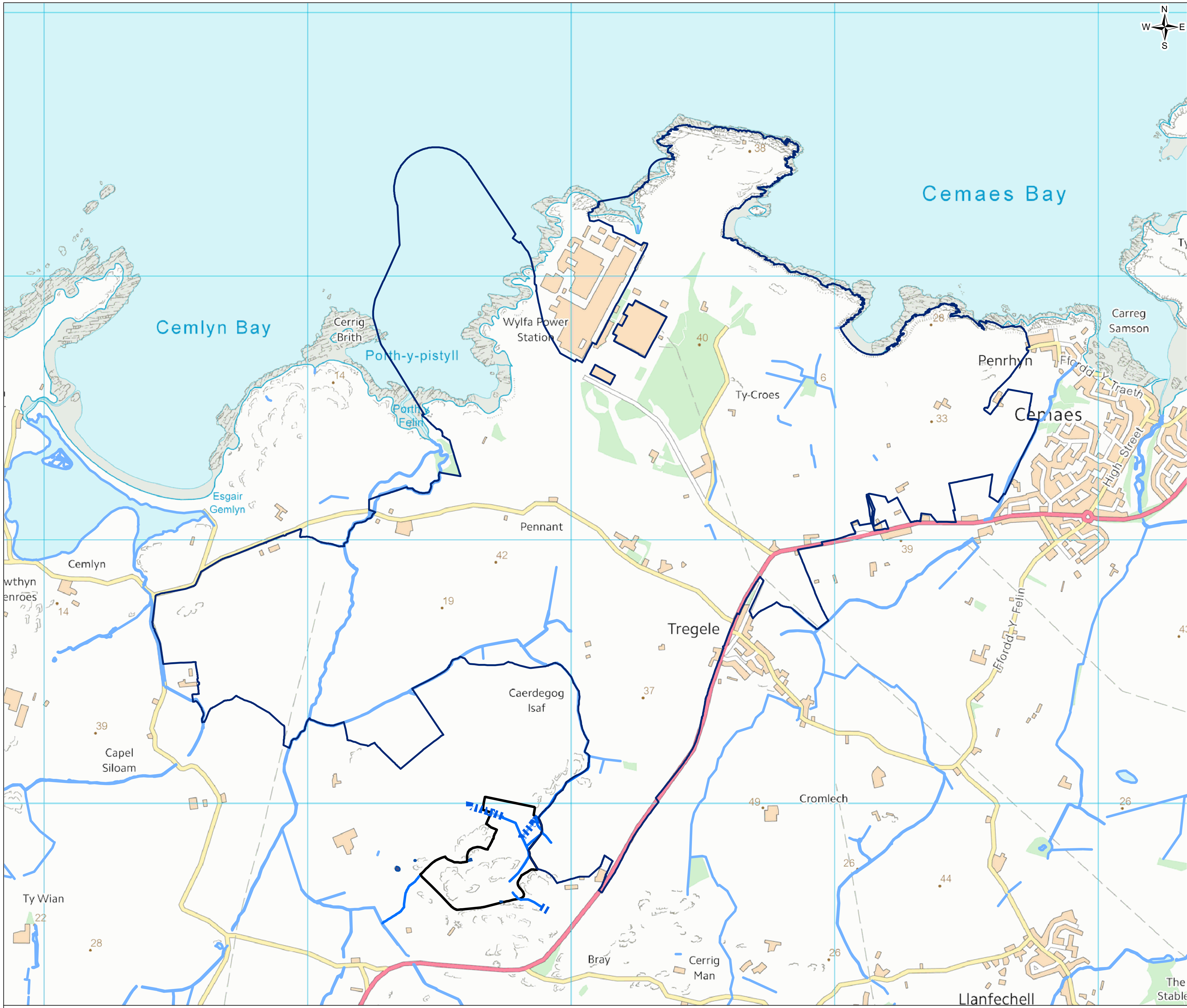
The main gaps in the current conceptual understanding of the hydrological functioning of the SSSI are the flows in the Southern Drain and Road Drain and to a lesser degree flows from Cae Gwyn and the effect of igneous intrusions on groundwater levels.

6. References

ID	Reference
RD1	Department of Energy and Climate Change, 2011, *National Policy Statement for Nuclear Power Generation (EN-6)* (NPS EN-6). London: The Stationery Office.
RD2	Atkins, 2015, Wylfa Newydd Nuclear Power Station – Detailed Onshore Ground Investigation Final Interpretative Ground Investigation Report. DCRM Ref Number WN02.03.01-ATK-SDT-REP-00001ATK-SDT-REP-00001.
RD3	National Soil Resources Institute, 2015, *Soils Site Report Full Site Report for National Grid Reference SH3591792942*. Cranfield University.
RD4	Countryside Council for Wales (CCW), 2005, *Lowland Peatland Survey Site Report: Cae Gwyn SSSI.*
RD5	Jacobs. 2015. Wylfa Newydd Technical Summary Report - National Vegetation Classification. WN034-JAC-PAC-REP-00003.
RD6	British Geological Survey, 2016, Geology of Britain Viewer. [Online] [Accessed on 16/10/16]. Available from: http://mapapps.bgs.ac.uk/geologyofbritain/home.html.
RD7	Countryside Council for Wales, 1982, *Cae Gwyn Site of Special Scientific Interest.* [Online] [Accessed 19/10/16]. Available from: http://angleseynature.co.uk/webmaps/caegwyn.html.
RD8	UK Technical Advisory Group on the Water Framework Directive, 2005, *Draft Protocol for determining "Significant Damage" to a "Groundwater Dependent Terrestrial Ecosystem"*.
RD9	Natural Resources Wales. 14 July 2017. Cae Gwyn SSSI Hydroecological Assessment, letter from NRW to Horizon regarding review of Cae Gwyn SSSI Hydroecological Assessment Report.
RD10	Bosanquet, S.D.S., Jones, P.S., Reed, D.K., Birch, K.S. & Turner, A.J., 2013, *Lowland Peatland Survey of Wales – Survey Manual.* CCW Staff Science Report No 13/3/2.
RD11	Price, J. 1996. Soil moisture, water tension, and water table relationships in a managed cutover bog. Journal of Hydrology. Elsevier. Vol. 292, Issues 1-4, December 1997, pp. 21-32.
RD12	Turner, A., 2006, Guidelines to NVC Community Definition for the M17/M18/M21/M2/Nodum 19 Complex in Wales. CCW Internal Report.
RD13	Ellis, S, 2016, [pers com email] *Cae Gwyn site condition.*
RD14	McBride, A. et al (eds). 2011. The Fen Management Handbook. Scottish Natural Heritage, Perth.
RD15	UKTAG, 2015, Technical report on groundwater dependent terrestrial ecosystem (GWDTE) threshold values.

Figures

FIGURE D8-6-1-1



Legend

- Wylfa Newydd Development Area
- Cae Gwyn SSSI Boundary
- Watercourse
- Open Water

SW Flow Pathways

- Ditch / formal drain
- Wetted informal flow pathway

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

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Client

HORIZON NUCLEAR POWER

Project

WYLFA NEWYDD PROPOSED NUCLEAR POWER STATION
CAE GWYN SSSI CONCEPTUAL MODEL REPORT

Drawing Title

CAE GWYN SSSI LOCATION

Drawing Status

Scale @ A3	1:14,000	DO NOT SCALE
Jacobs No.	60PO8058	
Client No.		

Drawing No.

60PO8058_DCO_APP_D8_06_01_01

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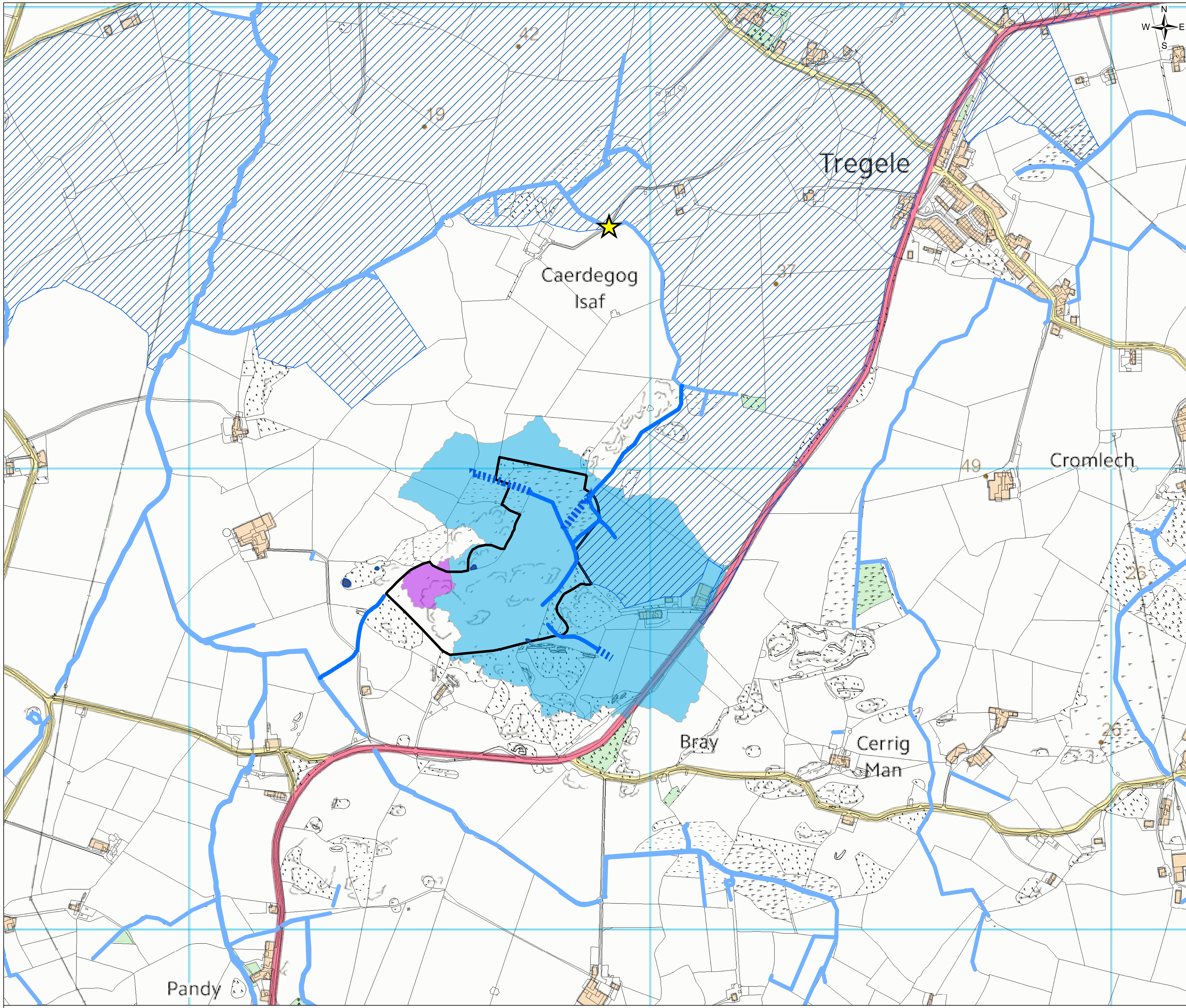
FIGURE D8-6-1-2

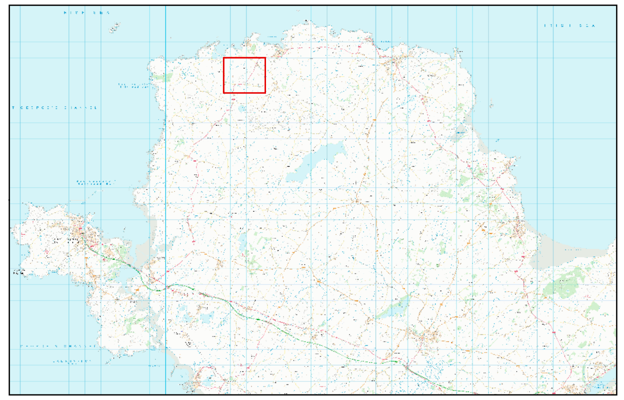


Legend

- Wylfa Newydd Development Area
- Cae Gwyn SSSI Boundary
- Primary Outflow Catchment
- Western Catchment
- Watercourse
- Open Water
- Monitoring Point - Location A

SW Flow Pathways

- Ditch / formal drain
- Wetted informal flow pathway



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

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WYLFA NEWYDD PROPOSED NUCLEAR POWER STATION
CAE GWYN SSSI CONCEPTUAL MODEL REPORT

Drawing Title

CAE GWYN LOCATION AND CATCHMENT AREA

Drawing Status

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Drawing No.

60PO8058_DCO_APP_D8_06_01_02

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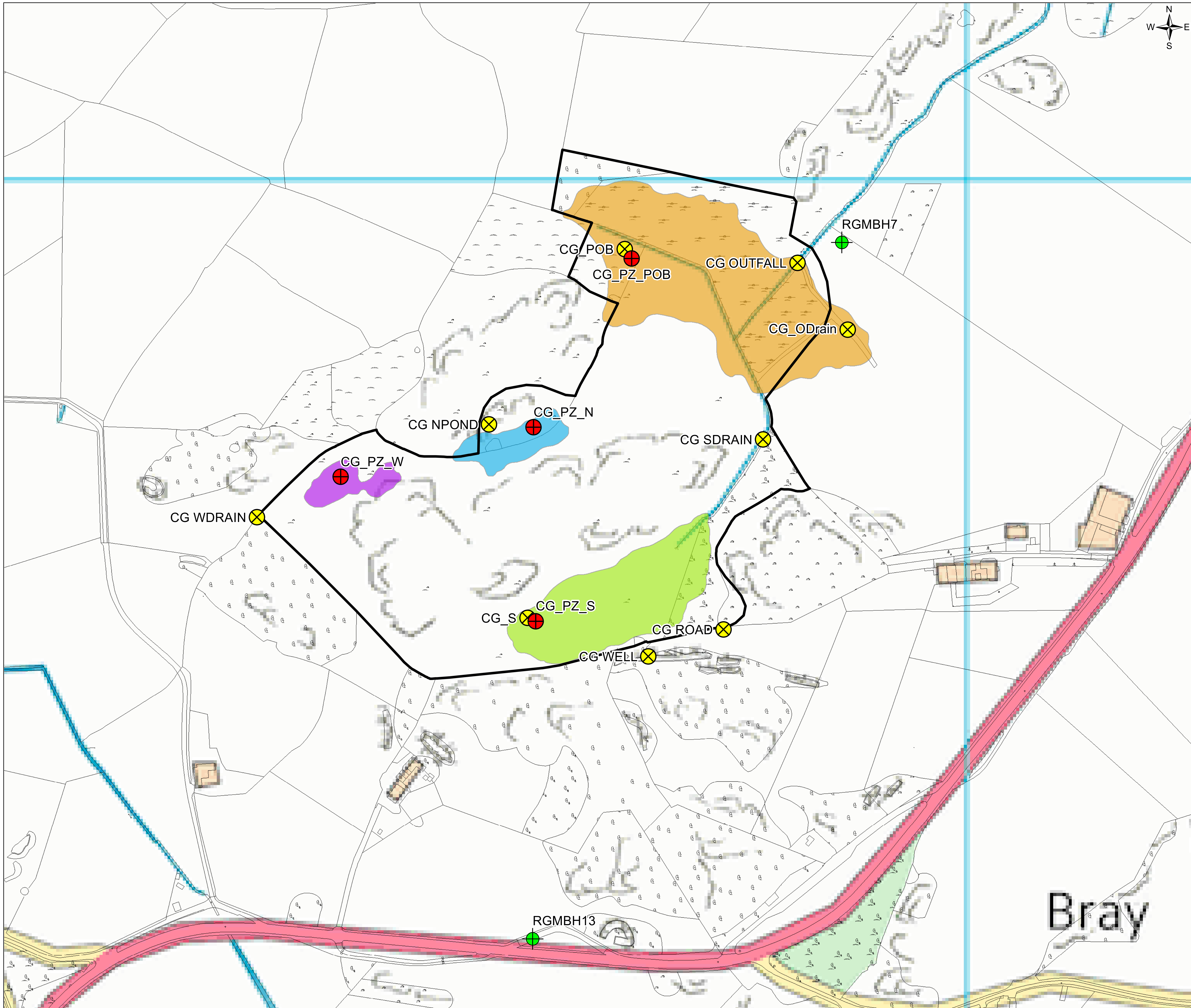
FIGURE D8-6-1-3

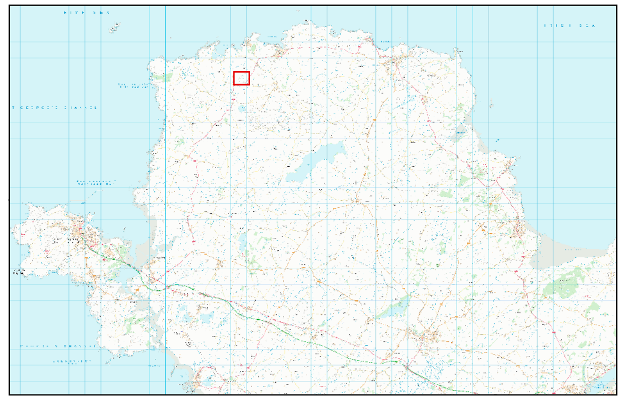


Legend

- Cae Gwyn SSSI Boundary
- Borehole
- Piezometer
- Surface Water Monitoring Locations

Basin Area

- Northern basin
- Southern basin
- Western basin
- Outflow basin



Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
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Client
HORIZON NUCLEAR POWER

Project
WYLFA NEWYDD PROPOSED NUCLEAR POWER STATION
CAE GWYN SSSI

Drawing Title
CAE GWYN MONITORING LOCATIONS

Drawing Status

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Drawing No.
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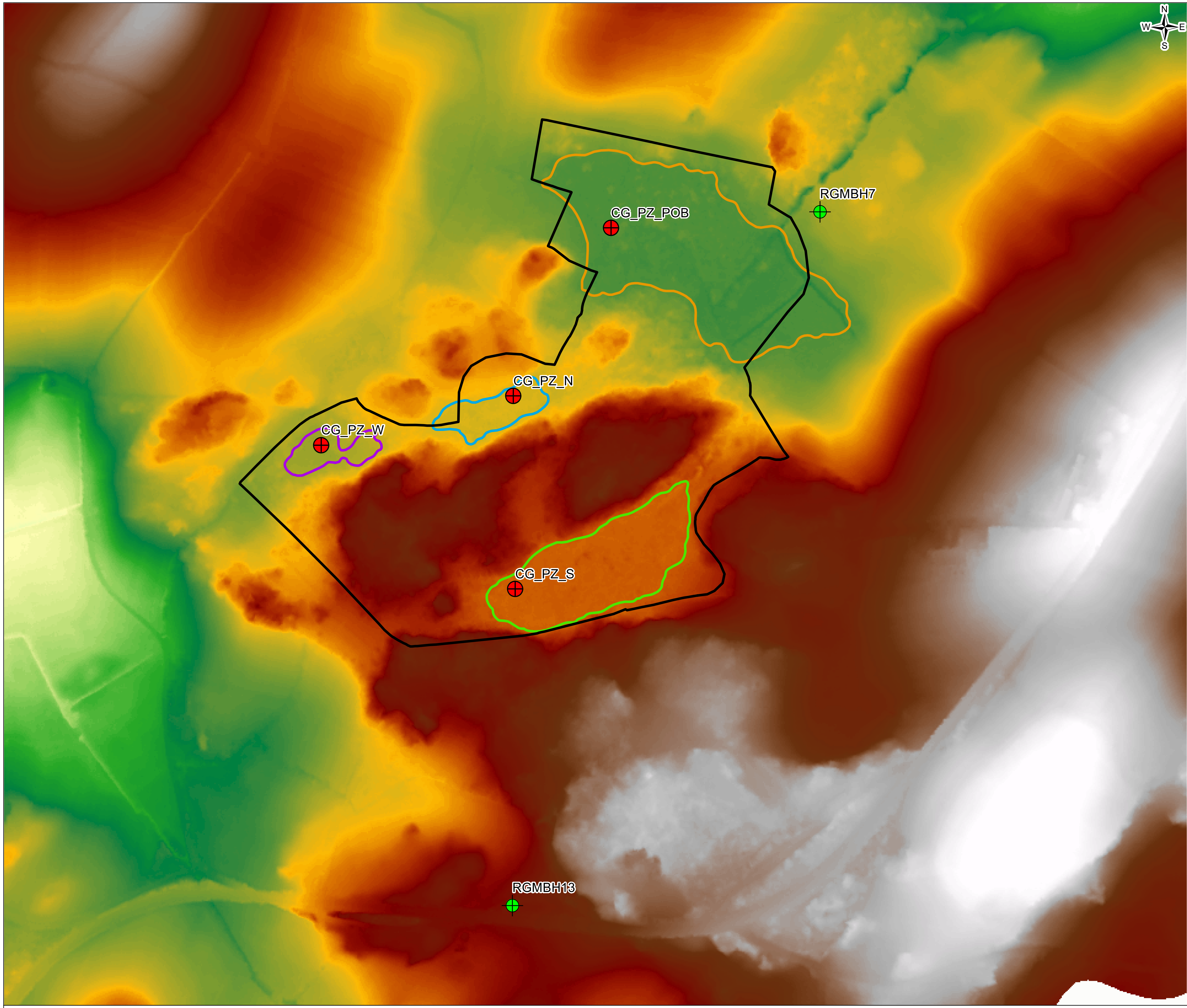


0 25 50 100 150 200 250 Metres

FIGURE D8-6-2-1

Legend

- Cae Gwyn SSSI Boundary
- Borehole
- Piezometer

Basin Area

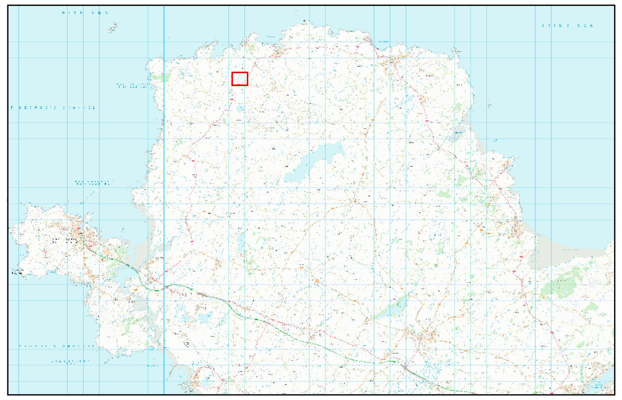
- Northern basin
- Southern basin
- Western basin
- Outflow basin

LiDAR Elevations

Value

High : 48.86

Low : 12.8



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Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd

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HORIZON NUCLEAR POWER

Project

WYLFA NEWYDD PROPOSED NUCLEAR POWER STATION
CAE GWYN SSSI

Drawing Title

CAE GWYN BASINS AND TOPOGRAPHY

Drawing Status

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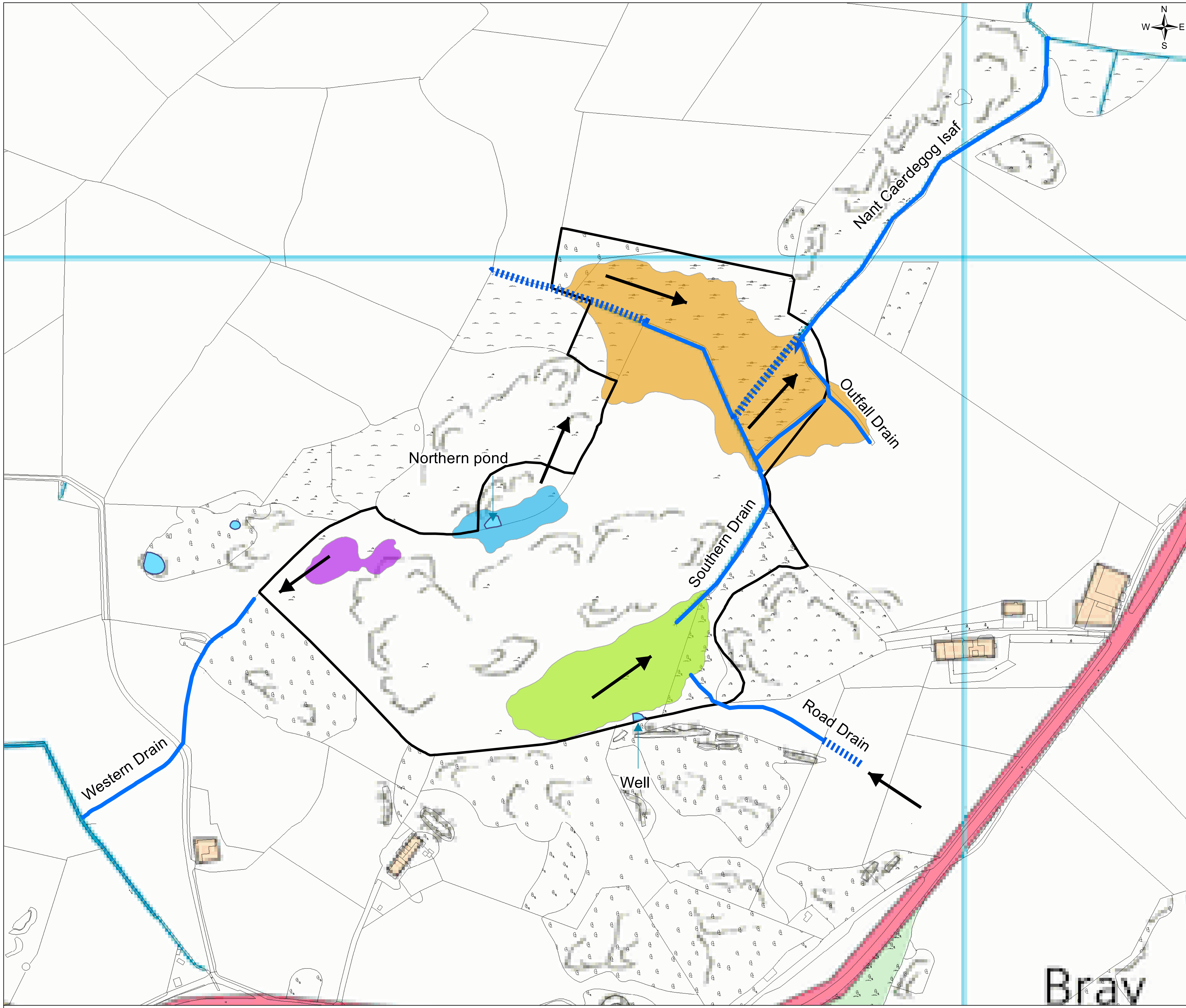
Client No.		
Drawing No.	60PO8058_DCO_APP_D8_06_02_01	

FIGURE D8-6-2-2



Legend

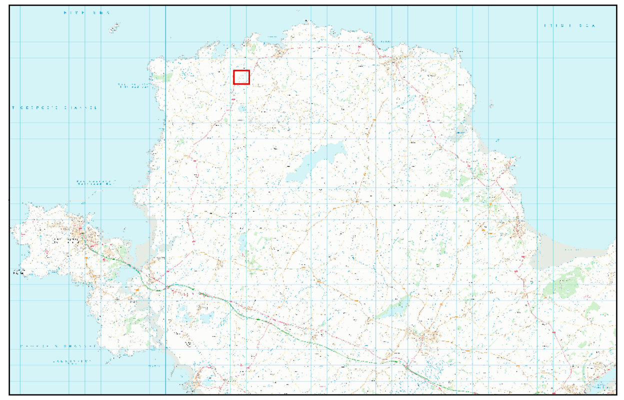
- Cae Gwyn SSSI Boundary
- Watercourse
- Open Water
- SW Flow Direction

Basin Area

- Northern basin
- Southern basin
- Western basin
- Outflow basin

SW Flow Pathways

- Ditch / formal drain
- Wetted informal flow pathway



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

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Client

HORIZON NUCLEAR POWER

Project

WYLFA NEWYDD PROPOSED NUCLEAR POWER STATION
CAE GWYN SSSI CONCEPTUAL MODEL REPORT

Drawing Title

CAE GWYN SURFACE WATER FEATURES AND FLOW DIRECTIONS

Drawing Status

Scale @ A3	1:3,000	DO NOT SCALE
Jacobs No.	60PO8058	
Client No.		

Drawing No.

60PO8058_DCO_APP_D8_06_02_02

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0 25 50 100 150 200 250 Metres

Figure D8-6-2-3 Water levels below ground level recorded in the piezometers and boreholes

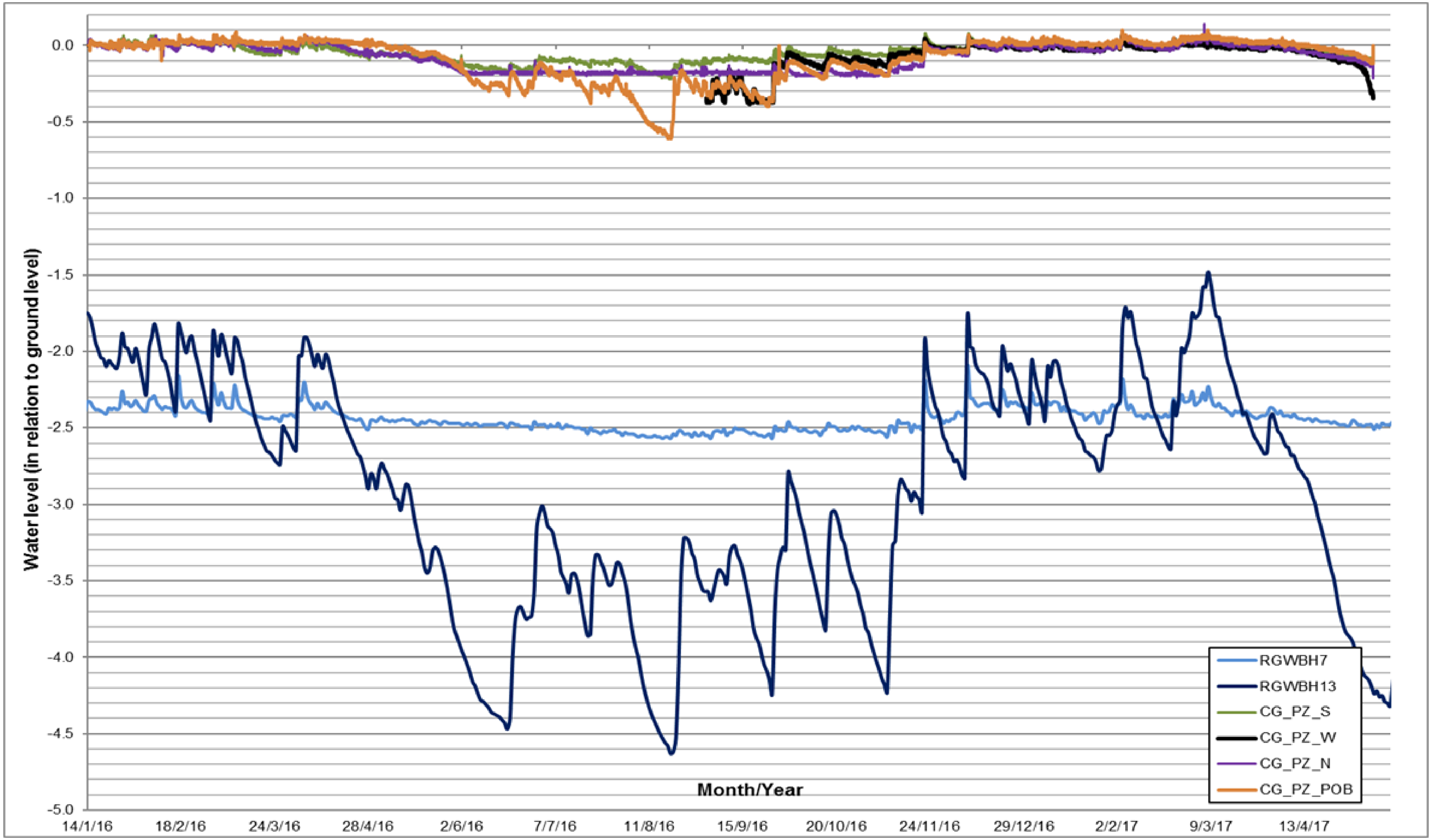
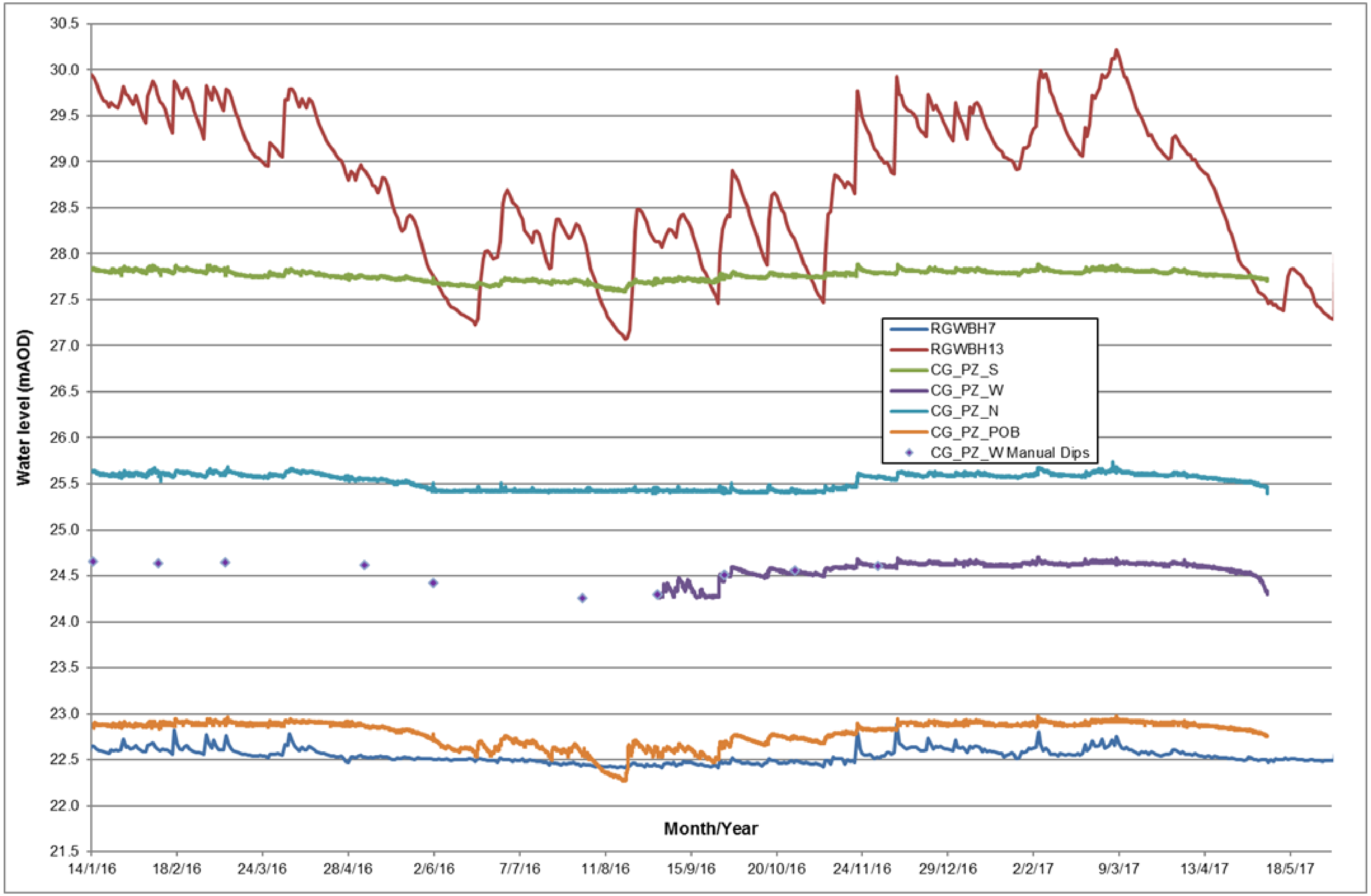


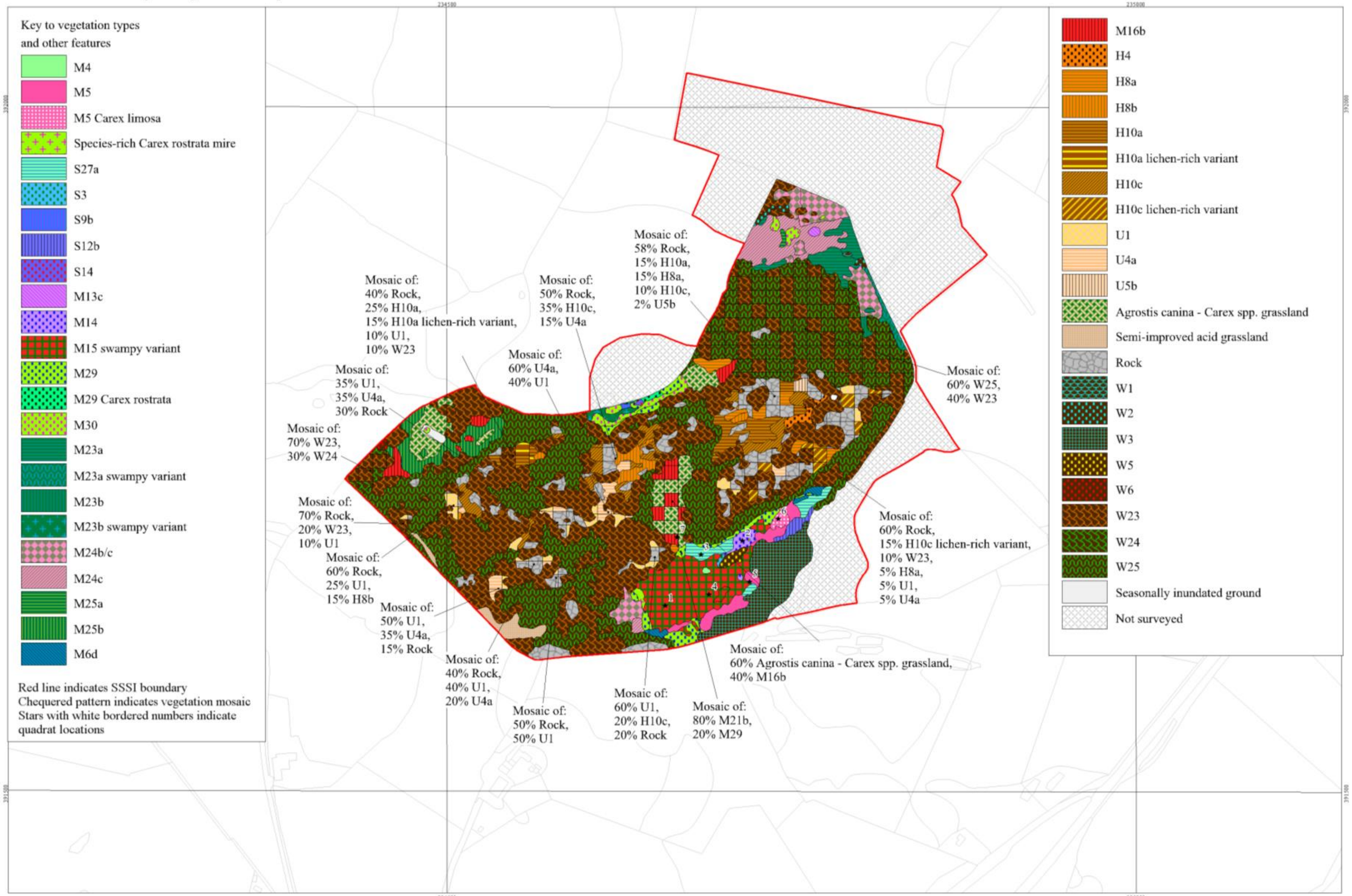
Figure D8-6-2-4 Water levels mAOD recorded in the piezometers and boreholes



Annexes

Annex A. Vegetation map

SH39/09P Cae Gwyn: vegetation map



Mapped by A. Turner, CCW 2005
Scale 1:2500

Cyfoeth Naturiol Cymru
Natural Resources Wales

Annex B. Borehole installation details

STRUCTURAL SOILS

BOREHOLE LOG

Contract:	Client:	Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation	Horizon Nuclear Power Wylfa Limited	RGM-BH7

Contract Ref:	Start: 11.11.14 / End: 12.11.14	Ground Level (m AOD):	National Grid Co-ordinate:	Sheet:
728599	Start: 11.11.14 End: 12.11.14	24.65	E:234898.6 N:391949.7	1 of 4

Depth	TCR %	SCR %	RQD %	If (mm)	Flush Returns & Details	Drill Time (hh:mm:ss)	Description of Strata	Reduced Level	Depth (Thickness)	Material Graphic Legend
0.00							Grass over soft brown slightly sandy slightly gravelly CLAY. (Topsoil)	24.50	0.15	
				NI	Water (Grey)	(0:05:00)	Strong greyish brown angular boulders of PSAMMITE with brown clay infill (Material cored).	24.15	(0.35) 0.50	
1.00						(00:15:00)	Borehole progressed using open hole drilling techniques; descriptions based on recovered chippings.	23.15	(1.00) 1.50	OH
2.00					Water (Grey)	(0:10:00)	Medium strong narrowly to very thinly banded very narrowly foliated greenish grey fine to coarse grained fresh PSAMMITE with weak to medium strong very closely spaced to closely spaced very narrow to narrow bands of very narrowly foliated greyish green PHYLLITE. (New Harbour Group - PSAMMITE)	22.65	(0.50) 2.00	
						(00:15:00)	Zone of no recovery. (New Harbour Group - PSAMMITE)	21.75	(0.90) 2.90	AZCL
3.00				10 350 900	Water (Grey)	(0:17:00)	Medium strong narrowly to very thinly banded very narrowly foliated greenish grey fine to coarse grained fresh PSAMMITE with weak to medium strong very closely spaced to closely spaced very narrow to narrow bands of very narrowly foliated greyish green PHYLLITE. (New Harbour Group - PSAMMITE)			
4.00					Water (Grey)	(0:25:00)				

Drilling Progress and Water Observations

Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
11/11/14	16:30	7.70	7.70	146	5.80

General Remarks

1. Location CAT and Genny scanned prior to commencement.
2. Hand dug inspection pit GL to 0.60m depth.(IP)
3. Rotary open hole drilling from 0.60m to 1.50m depth and 2.00m to 2.90m depth on 11/11/2014.
4. Rotary cored drilling from 0.30m to 0.60m depth, 1.50m to 2.00m depth and 2.90m to 13.95m depth with water and air mist flush between 11/11/2014 and 12/11/2014.

All dimensions in metres | Scale: 1:25 | Inclination: Vertical | Azimuth: NA

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary Cored + Rotary open hole	Comacchio GEO 601	Scott Pincher	KWhitcombe + MSummersall	ADingle + ADingle + ADingle +

STRUCTURAL SOILS

BOREHOLE LOG

Contract: Wylfa Newydd Detailed Onshore Ground Investigation	Client: Horizon Nuclear Power Wylfa Limited	Borehole: RGM-BH7
Contract Ref: 728599	Start: 11.11.14 End: 12.11.14	Ground Level (m AOD): 24.65
National Grid Co-ordinate: E:234898.6 N:391949.7	Sheet: 2 of 4	

Depth	TCR %	SCR %	RQD %	If (mm)	Flush Returns & Details	Drill Time (hh:mm:ss)	Sampling	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
5.00				10 350 900	Water (Grey)	(0:25:00)						20	5	
6.00				NI	Water (Grey)	(0:22:00)						19	(5.85) 6	
7.00				10 450 1,250	Water (Grey)	(0:22:00)						18 / 17	7	
8.00					Air+Mist (Grey)	(0:14:00)				Medium strong narrowly to thinly banded very narrowly foliated greenish grey fine to coarse grained fresh		16 / 15.90	8 / 8.75 / 9	

Drilling Progress and Water Observations

Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
11/11/14	16:30	7.70	7.70	146	5.80

General Remarks

5. Groundwater monitoring standpipe installed as shown upon completion.

All dimensions in metres | Scale: 1:25 | Inclination: Vertical | Azimuth: NA

Method Used: Inspection pit + Rotary Cored + Rotary open hole | Plant Used: Comacchio GEO 601 | Drilled By: Scott Pincher | Logged By: KWhitcombe + MSummersall | Reviewed By: ADingle + ADingle + ADingle +

STRUCTURAL SOILS

[DI-126] - Issued to client for approval

BOREHOLE LOG

Contract:	Client:	Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation	**Horizon Nuclear Power Wylfa Limited**	**RGM-BH7**

Contract Ref:	Start / End	Ground Level (m AOD):	National Grid Co-ordinate:	Sheet:
728599	Start: **11.11.14** End: **12.11.14**	**24.65**	**E:234898.6 N:391949.7**	**3** of **4**

Depth	TCR %	SCR %	RQD %	If (mm)	Flush Returns & Details	Drill Time (hh:mm:ss)	Sampling	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
9.00					Air+Mist (Grey)	(0:14:00)				PSAMMITE with weak to medium strong very closely spaced to closely spaced very narrow to narrow bands of very narrowly foliated greyish green PHYLLITE. (New Harbour Group - PSAMMITE)		15		
10.00					Air+Mist (Grey)	(0:18:00)						14	10	
11.00				240 400 2,000	Air+Mist (Grey)	(0:15:00)						13	11 (5.20)	
12.00												12	12	
13.00					Air+Mist (Grey)	(0:10:00)							13	

Drilling Progress and Water Observations

Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
11/11/14	16:30	7.70	7.70	146	5.80

General Remarks

All dimensions in metres | Scale: **1:25** | Inclination: **Vertical** | Azimuth: **NA**

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary Cored + Rotary open hole	**Comacchio GEO 601**	**Scott Pincher**	**KWhitcombe + MSummersall**	**ADingle + ADingle + ADingle +**

[DI-126] - Issued to client for approval

STRUCTURAL SOILS

BOREHOLE LOG

Contract:	Client:	Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation	Horizon Nuclear Power Wylfa Limited	RGM-BH7

Contract Ref:	Start:	Ground Level (m AOD):	National Grid Co-ordinate:	Sheet:
728599	Start: 11.11.14 End: 12.11.14	24.65	E:234898.6 N:391949.7	4 of 4

Depth	TCR %	SCR %	RQD %	If (mm)	Flush Returns & Details	Drill Time (hh:mm:ss)	Sampling	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
				240 400 2,000	Air+Mist (Grey)	(0:10:00)						11 10.70	13.95	
										Borehole terminated at 13.95m depth.			14	

Drilling Progress and Water Observations					
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
11/11/14	16:30	7.70	7.70	146	5.80

General Remarks

All dimensions in metres | Scale: 1:25 | Inclination: Vertical | Azimuth: NA

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary Cored + Rotary open hole	Comacchio GEO 601	Scott Pincher	KWhitcombe + MSummersall	ADingle + ADingle + ADingle +

STRUCTURAL SOILS

[DI-126] - Issued to client for approval

BOREHOLE LOG

Contract:	Client:	Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation	**Horizon Nuclear Power Wylfa Limited**	**RGM-BH7**

Contract Ref:	Start: / End:	Ground Level (m AOD):	National Grid Co-ordinate:	Sheet:
728599	Start: **11.11.14** End: **12.11.14**	**24.65**	**E:234898.6 N:391949.7**	**1** of **18**

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
0.00						1	EW				Grass over soft brown slightly sandy slightly gravelly CLAY. (Topsoil)		24.50	(0.15) 0.15	
0.30-0.60 (0:05)	100	0	0	NI	Water (Grey)						Strong greyish brown angular boulders of PSAMMITE with brown clay infill (Material cored). For details of rock see core run log. 0.30-0.60m : Recovered as angular cored segments of medium to coarse grained slightly weathered to fresh grey psammite with occasional iron staining on surfaces.		24.15	(0.35) 0.50	
											Borehole progressed using open hole drilling techniques; descriptions based on recovered chippings.		24		OH

Drilling Progress and Water Observations

Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
11/11/14	16:30	7.70	7.70	146	5.80

General Remarks

1. Location CAT and Genny scanned prior to commencement.
2. Hand dug inspection pit GL to 0.60m depth.(IP)
3. Rotary open hole drilling from 0.60m to 1.50m depth and 2.00m to 2.90m depth on 11/11/2014.
4. Rotary cored drilling from 0.30m to 0.60m depth, 1.50m to 2.00m depth and 2.90m to 13.95m depth with water and air mist flush between 11/11/2014 and 12/11/2014.

All dimensions in metres | Scale: **1:5** | Inclination: **Vertical** | Azimuth: **NA**

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary Cored + Rotary open hole	**Comacchio GEO 601**	**Scott Pincher**	**KWhitcombe + MSummersall**	**ADingle + ADingle + ADingle +**

STRUCTURAL SOILS

[DI-126] - Issued to client for approval

BOREHOLE LOG

Contract: Wylfa Newydd Detailed Onshore Ground Investigation		Client: Horizon Nuclear Power Wylfa Limited		Borehole: RGM-BH7
Contract Ref: 728599	Start: 11.11.14 End: 12.11.14	Ground Level (m AOD): 24.65	National Grid Co-ordinate: E:234898.6 N:391949.7	Sheet: 2 of 18

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
														(1.00)	OH
1.50-2.00 (0:10)	100	60	0	10 350 900	Water (Grey)						Medium strong narrowly to very thinly banded very narrowly foliated greenish grey fine to coarse grained fresh PSAMMITE with weak to medium strong very closely spaced to closely spaced very narrow to narrow bands of very narrowly foliated greyish green PHYLLITE. Foliation is sub-horizontal to shallowly dipping. Occasional shallowly to steeply dipping sigmoidal calcite veins concentrated between phyllite bands. Rare ptygmatic chlorite/epidote micro-veining within psammite bands. Foliation fractures are sub-horizontal to shallowly dipping extremely closely to widely spaced planar to undulating rough/smooth open clean with some slight patchy calcite infill and local green discolouration. (New Harbour Group -		23.15	1.50 (0.50)	

Drilling Progress and Water Observations					
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
11/11/14	16:30	7.70	7.70	146	5.80

General Remarks

5. Groundwater monitoring standpipe installed as shown upon completion.

All dimensions in metres | Scale: 1:5 | Inclination: Vertical | Azimuth: NA

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary Cored + Rotary open hole	Comacchio GEO 601	Scott Pincher	KWhitcombe + MSummersall	ADingle + ADingle + ADingle +

STRUCTURAL SOILS

BOREHOLE LOG

Contract: Wylfa Newydd Detailed Onshore Ground Investigation	Client: Horizon Nuclear Power Wylfa Limited	Borehole: RGM-BH7
Contract Ref: 728599 / Start: 11.11.14 / End: 12.11.14 / Ground Level (m AOD): 24.65	National Grid Co-ordinate: E:234898.6 N:391949.7	Sheet: 3 of 18

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
	100	60	0		Water (Grey)						PSAMMITE) 1.80-2.00m : Collapsed material from open hole method, dark brown silty CLAY with frequent angular cobble sized cored segments of fine to medium grained grey psammite.		22.65	2.00	
2				10 350 900							Zone of no recovery. (New Harbour Group - PSAMMITE)			(0.90)	AZCL
													22		

Drilling Progress and Water Observations					
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
11/11/14	16:30	7.70	7.70	146	5.80

General Remarks

All dimensions in metres | Scale: 1:5 | Inclination: Vertical | Azimuth: NA

Method Used: Inspection pit + Rotary Cored + Rotary open hole | Plant Used: Comacchio GEO 601 | Drilled By: Scott Pincher | Logged By: KWhitcombe + MSummersall | Reviewed By: ADingle + ADingle + ADingle +

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STRUCTURAL SOILS

BOREHOLE LOG

Contract: Wylfa Newydd Detailed Onshore Ground Investigation	Client: Horizon Nuclear Power Wylfa Limited	Borehole: RGM-BH7
Contract Ref: 728599	Start: 11.11.14 End: 12.11.14	Ground Level (m AOD): 24.65
National Grid Co-ordinate: E:234898.6 N:391949.7	Sheet: 4 of 18	

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
								21.75	2.90	AZCL
2.90-3.40 (0:17)	100	100	100	10 350 900	Water (Grey)	Medium strong narrowly to very thinly banded very narrowly foliated greenish grey fine to coarse grained fresh PSAMMITE with weak to medium strong very closely spaced to closely spaced very narrow to narrow bands of very narrowly foliated greyish green PHYLLITE. Foliation is sub-horizontal to shallowly dipping. Occasional shallowly to steeply dipping sigmoidal calcite veins concentrated between phyllite bands. Rare ptygmatic chlorite/epidote micro-veining within psammite bands. Foliation fractures are sub-horizontal to shallowly dipping extremely closely to widely spaced planar to undulating rough/smooth open clean with some slight patchy calcite infill and local green discolouration. (New Harbour Group - PSAMMITE)	1 FF[i]		3	
3.40-5.00 (0:25)	100	100	88		Water (Grey)		2 FF[i] 3 FF[i]			

Drilling Progress and Water Observations

Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
11/11/14	16:30	7.70	7.70	146	5.80

General Remarks 21

All dimensions in metres | Scale: 1:5 | Inclination: Vertical | Azimuth: NA

Method Used: Inspection pit + Rotary Cored + Rotary open hole | Plant Used: Comacchio GEO 601 | Drilled By: Scott Pincher | Logged By: KWhitcombe + MSummersall | Reviewed By: ADingle + ADingle + ADingle +

BOREHOLE LOG

Contract:	Client:	Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation	Horizon Nuclear Power Wylfa Limited	RGM-BH7

Contract Ref:	Start: 11.11.14 / End: 12.11.14	Ground Level (m AOD):	National Grid Co-ordinate:	Sheet:
728599	Start: 11.11.14 End: 12.11.14	24.65	E:234898.6 N:391949.7	5 of 18

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
	100	100	88	10 350 900	Water (Grey)							4 FF[i] 5 FF[i] 6 FF[i] 7 FF[i] 8 FF[i] 9 FF[i]	21	4	

Drilling Progress and Water Observations

Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
11/11/14	16:30	7.70	7.70	146	5.80

General Remarks

All dimensions in metres | Scale: 1:5 | Inclination: Vertical | Azimuth: NA

Method Used: Inspection pit + Rotary Cored + Rotary open hole | Plant Used: Comacchio GEO 601 | Drilled By: Scott Pincher | Logged By: KWhitcombe + MSummersall | Reviewed By: ADingle + ADingle + ADingle +

[DI-126] - Issued to client for approval

STRUCTURAL SOILS

BOREHOLE LOG

Contract:	Client:	Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation	Horizon Nuclear Power Wylfa Limited	RGM-BH7

Contract Ref:	Start: 11.11.14 / End: 12.11.14	Ground Level (m AOD):	National Grid Co-ordinate:	Sheet:
728599	Start: 11.11.14 End: 12.11.14	24.65	E:234898.6 N:391949.7	6 of 18

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
	100	100	88		Water (Grey)							10 FF[i]	20		
				10 350 900											
5.00-6.50 (0:22)	97	83	83		Water (Grey)						5.37m : Dissolution voids and some orange iron staining in			5	

Drilling Progress and Water Observations

Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
11/11/14	16:30	7.70	7.70	146	5.80

General Remarks

All dimensions in metres | Scale: 1:5 | Inclination: Vertical | Azimuth: NA

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary Cored +	Comacchio GEO 601	Scott Pincher	KWhitcombe + MSummersall	ADingle + ADingle +

STRUCTURAL SOILS

BOREHOLE LOG

Contract:	Client:	Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation	Horizon Nuclear Power Wylfa Limited	RGM-BH7

Contract Ref:	Start:	Ground Level (m AOD):	National Grid Co-ordinate:	Sheet:
728599	Start: 11.11.14 / End: 12.11.14	24.65	E:234898.6 N:391949.7	7 of 18

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
											calcite veins.				
												11 FF[i]			
													19		
				10 350 900											
														(5.85)	
	97	83	83		Water (Grey)										
6															
											6.10-6.40m : Recovered as subangular medium to coarse gravel of grey psammite. Drilling induced.				
				NI											

Drilling Progress and Water Observations

Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
11/11/14	16:30	7.70	7.70	146	5.80

General Remarks

All dimensions in metres | Scale: 1:5 | Inclination: Vertical | Azimuth: NA

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary Cored + Rotary open hole	Comacchio GEO 601	Scott Pincher	KWhitcombe + MSummersall	ADingle + ADingle + ADingle +

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STRUCTURAL SOILS

BOREHOLE LOG

Contract: Wylfa Newydd Detailed Onshore Ground Investigation	Client: Horizon Nuclear Power Wylfa Limited	Borehole: RGM-BH7
Contract Ref: 728599	Start: 11.11.14 End: 12.11.14	Ground Level (m AOD): 24.65
National Grid Co-ordinate: E:234898.6 N:391949.7	Sheet: 8 of 18	

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instru-mentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
	97	83	83	NI	Water (Grey)										
6.50-7.90 (0:22)	100	100	100	10 450 1,250	Water (Grey)								18	7	
												12 FF[i] 13 FF[i]			

Drilling Progress and Water Observations					
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
11/11/14	16:30	7.70	7.70	146	5.80

General Remarks

All dimensions in metres | Scale: 1:5 | Inclination: Vertical | Azimuth: NA

Method Used: Inspection pit + Rotary Cored + Rotary open hole | Plant Used: Comacchio GEO 601 | Drilled By: Scott Pincher | Logged By: KWhitcombe + MSummersall | Reviewed By: ADingle + ADingle + ADingle +

[DI-126] - Issued to client for approval

STRUCTURAL SOILS

BOREHOLE LOG

Contract:	Client:	Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation	Horizon Nuclear Power Wylfa Limited	RGM-BH7

Contract Ref:	Start: 11.11.14	Ground Level (m AOD):	National Grid Co-ordinate:	Sheet:
728599	End: 12.11.14	24.65	E:234898.6 N:391949.7	9 of 18

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
	100	100	100		Water (Grey)										
				10 450 1,250									17		
7.90-9.50 (0:14)	100	98	84		Air+Mist (Grey)									8	

Drilling Progress and Water Observations

Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
11/11/14	16:30	7.70	7.70	146	5.80

General Remarks

All dimensions in metres | Scale: 1:5 | Inclination: Vertical | Azimuth: NA

Method Used: Inspection pit + Rotary Cored + Rotary open hole | Plant Used: Comacchio GEO 601 | Drilled By: Scott Pincher | Logged By: KWhitcombe + MSummersall | Reviewed By: ADingle + ADingle + ADingle +

STRUCTURAL SOILS

BOREHOLE LOG

Contract:	Client:	Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation	Horizon Nuclear Power Wylfa Limited	RGM-BH7

Contract Ref:	Start: 11.11.14	Ground Level (m AOD):	National Grid Co-ordinate:	Sheet:
728599	End: 12.11.14	24.65	E:234898.6 N:391949.7	10 of 18

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)
	100	98	84	10 450 1,250	Air+Mist (Grey)						8.50-8.56m : Slightly weathered/fractured quartz vein with occasional iron staining and calcite dissolution pitting.	14 FF[i] 15 FF[i] 16 FF[i] 17 FF[i]	16 15.90	8.75
9											Medium strong narrowly to thinly banded very narrowly foliated greenish grey fine to coarse grained fresh PSAMMITE with weak to medium strong very closely spaced to closely spaced very narrow to narrow bands of very narrowly foliated greyish green PHYLLITE. Foliation is sub-horizontal to shallowly dipping. Rare shallowly to steeply dipping sigmoidal calcite veins concentrated between phyllite bands. Rare sporadic ptygmatic chlorite/epidote micro-veining within psammite bands. Foliation fractures are sub-horizontal to shallowly dipping extremely closely to widely spaced planar to undulating rough open clean			

Drilling Progress and Water Observations

Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
11/11/14	16:30	7.70	7.70	146	5.80

General Remarks

All dimensions in metres | Scale: 1:5 | Inclination: Vertical | Azimuth: NA

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary Cored + Rotary openhole	Comacchio GEO 601	Scott Pincher	KWhitcombe + MSummersall	ADingle + ADingle + ADingle +

Structural Soils Ltd, Head Office - Bristol: The Old School, Stillhouse Lane, Bedminster, Bristol, BS3 4EB. Tel: 0117-947-1000, Fax: 0117-947-1004, Web: www.soils.co.uk, Email: ask@soils.co.uk

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STRUCTURAL SOILS

BOREHOLE LOG

Contract: Wylfa Newydd Detailed Onshore Ground Investigation	Client: Horizon Nuclear Power Wylfa Limited	Borehole: RGM-BH7
Contract Ref: 728599	Start: 11.11.14 End: 12.11.14	Ground Level (m AOD): 24.65	National Grid Co-ordinate: E:234898.6 N:391949.7	Sheet: 11 of 18

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
	100	98	84	240 400 2,000	Air+Mist (Grey)						with some slight patchy calcite infill and local green discolouration. (New Harbour Group - PSAMMITE)				
9.50-11.10 (0:18)	100	100	100		Air+Mist (Grey)								15		

Drilling Progress and Water Observations					
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
11/11/14	16:30	7.70	7.70	146	5.80

General Remarks

All dimensions in metres | Scale: 1:5 | Inclination: Vertical | Azimuth: NA

Method Used: Inspection pit + Rotary Cored + Rotary open hole | Plant Used: Comacchio GEO 601 | Drilled By: Scott Pincher | Logged By: KWhitcombe + MSummersall | Reviewed By: ADingle + ADingle + ADingle +

STRUCTURAL SOILS

BOREHOLE LOG

Contract: Wylfa Newydd Detailed Onshore Ground Investigation	Client: Horizon Nuclear Power Wylfa Limited	Borehole: RGM-BH7
Contract Ref: 728599	Start: 11.11.14 End: 12.11.14	Ground Level (m AOD): 24.65
National Grid Co-ordinate: E:234898.6 N:391949.7	Sheet: 12 of 18	

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
	100	100	100	240 400 2,000	Air+Mist (Grey)							18 FF[i] 19 FF[i] 20 FF[i]	14	10	

Drilling Progress and Water Observations					
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
11/11/14	16:30	7.70	7.70	146	5.80

General Remarks

All dimensions in metres | Scale: 1:5 | Inclination: Vertical | Azimuth: NA

Method Used: Inspection pit + Rotary Cored + Rotary open hole | Plant Used: Comacchio GEO 601 | Drilled By: Scott Pincher | Logged By: KWhitcombe + MSummersall | Reviewed By: ADingle + ADingle + ADingle +

STRUCTURAL SOILS

BOREHOLE LOG

Contract:	Client:	Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation	Horizon Nuclear Power Wylfa Limited	RGM-BH7

Contract Ref:	Start: 11.11.14	Ground Level (m AOD):	National Grid Co-ordinate:	Sheet:
728599	End: 12.11.14	24.65	E:234898.6 N:391949.7	13 of 18

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
	100	100	100		Air+Mist (Grey)										
														11	
11.10-12.60 (0:15)															
				240 400 2,000											
														(5.20)	
	100	100	100		Air+Mist (Grey)										
											11.64m : Light green Dolerite apophysis shallowly dipping <20mm thick.		13		

Drilling Progress and Water Observations

Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
11/11/14	16:30	7.70	7.70	146	5.80

General Remarks

All dimensions in metres | Scale: 1:5 | Inclination: Vertical | Azimuth: NA

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary Cored + Rotary open hole	Comacchio GEO 601	Scott Pincher	KWhitcombe + MSummersall	ADingle + ADingle + ADingle +

STRUCTURAL SOILS

BOREHOLE LOG

Contract:		Client:		Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation		Horizon Nuclear Power Wylfa Limited		RGM-BH7
Contract Ref: 728599	Start: 11.11.14 End: 12.11.14	Ground Level (m AOD): 24.65	National Grid Co-ordinate: E:234898.6 N:391949.7	Sheet: 14 of 18

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
	100	100	100	240 400 2,000	Air+Mist (Grey)									12	

Drilling Progress and Water Observations					
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
11/11/14	16:30	7.70	7.70	146	5.80

General Remarks

12

All dimensions in metres | Scale: 1:5 | Inclination: Vertical | Azimuth: NA

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary Cored + Rotary open hole	Comacchio GEO 601	Scott Pincher	KWhitcombe + MSummersall	ADingle + ADingle + ADingle +

STRUCTURAL SOILS

BOREHOLE LOG

Contract:	Client:	Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation	Horizon Nuclear Power Wylfa Limited	RGM-BH7

Contract Ref:	Start: 11.11.14	Ground Level (m AOD):	National Grid Co-ordinate:	Sheet:
728599	End: 12.11.14	24.65	E:234898.6 N:391949.7	15 of 18

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
12.60-13.95 (0:10)	100	100	100	240 400 2,000	Air+Mist (Grey)								12	13	

Drilling Progress and Water Observations

Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
11/11/14	16:30	7.70	7.70	146	5.80

General Remarks

All dimensions in metres | Scale: 1:5 | Inclination: Vertical | Azimuth: NA

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary Cored + Rotary open hole	Comacchio GEO 601	Scott Pincher	KWhitcombe + MSummersall	ADingle + ADingle + ADingle +

STRUCTURAL SOILS

BOREHOLE LOG

Contract:		Client:	Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation		Horizon Nuclear Power Wylfa Limited	RGM-BH7
Contract Ref: 728599	Start: 11.11.14 End: 12.11.14	Ground Level (m AOD): 24.65	National Grid Co-ordinate: E:234898.6 N:391949.7
			Sheet: 16 of 18

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
	100	100	100	240 400 2,000	Air+Mist (Grey)								11 10.70	13.95	
											Borehole terminated at 13.95m depth.			14	

Drilling Progress and Water Observations					
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
11/11/14	16:30	7.70	7.70	146	5.80

General Remarks

All dimensions in metres | Scale: 1:5 | Inclination: Vertical | Azimuth: NA

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary Cored + Rotary open hole	Comacchio GEO 601	Scott Pincher	KWhitcombe + MSummersall	ADingle + ADingle + ADingle +

Contract:		Client:		Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation		Horizon Nuclear Power Wylfa Limited		RGM-BH7
Contract Ref: 728599	Start: 11.11.14 End: 12.11.14	Ground Level (m AOD): 24.65	National Grid Co-ordinate: E:234898.6 N:391949.7	Sheet: 17 of 18

RGM-BH7 Box 1-2 0.30m - 5.00m depth

RGM-BH7 Box 3-4 5.00m - 7.70m depth

Method Used:	Inspection pit + Rotary Cored + Rotary open hole	Plant Used:	Comacchio GEO 601	Drilled By:	Scott Pincher	Logged By:	KWhitcombe + MSummersall	Reviewed By:	ADingle + ADingle + ADingle + ADingle +

STRUCTURAL SOILS

[DI-126] - Issued to client for approval

BOREHOLE LOG

Contract: Wylfa Newydd Detailed Onshore Ground Investigation		Client: Horizon Nuclear Power Wylfa Limited		Borehole: RGM-BH7
Contract Ref: 728599	Start: 11.11.14 End: 12.11.14	Ground Level (m AOD): 24.65	National Grid Co-ordinate: E:234898.6 N:391949.7	Sheet: 18 of 18

RGM-BH7 Box 5-6 7.70m - 10.80m depth

RGM-BH7 Box 7-8 10.80m - 13.60m depth

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary Cored + Rotary open hole	Comacchio GEO 601	Scott Pincher	KWhitcombe + MSummersall	ADingle + ADingle + ADingle + ADingle +

SUMMARY OF DISCONTINUITIES - RGM-BH7

Fracture Number	Depth (m)	Fracture Type	Dip (deg)	Small Scale Roughness	Aperture Description	Infill Material Description	Remarks	Stratigraphic Layer	Lithological Facies
1	3.30	FF	9	P-R	Open	Clean		New Harbour Group	PSAMMITE
2	3.51	FF	9	P-R	Open	Clean		New Harbour Group	PSAMMITE
3	3.52	FF	11	P-SM	Open	Clean		New Harbour Group	PSAMMITE
4	3.63	FF	12	P-R	Open	Clean with patchy calcite infill		New Harbour Group	PSAMMITE
5	3.79	FF	10	P-R	Open	Clean		New Harbour Group	PSAMMITE
6	4.20	FF	13	P-R	Open	Clean		New Harbour Group	PSAMMITE
7	4.22	FF	10	P-R	Open	Clean with some green discolouration		New Harbour Group	PSAMMITE
8	4.30	FF	11	P-R	Open	Clean		New Harbour Group	PSAMMITE
9	4.35	FF	10	P-R	Open	Clean		New Harbour Group	PSAMMITE
10	4.73	FF	10	P-R	Open	Clean		New Harbour Group	PSAMMITE
11	5.52	FF	19	P-R	Open	Clean with some green discolouration		New Harbour Group	PSAMMITE
12	7.03	FF	11	U-R	Open	Clean		New Harbour Group	PSAMMITE
13	7.04	FF	11	U-R	Open	Clean with green discolouration		New Harbour Group	PSAMMITE
14	8.30	FF	11	P-R	Open	Clean with green discolouration		New Harbour Group	PSAMMITE
15	8.44	FF	12	P-R	Open	Clean with green discolouration		New Harbour Group	PSAMMITE
16	8.58	FF	12	P-R	Open	Clean with patchy calcite infill		New Harbour Group	PSAMMITE

Key:
Type codes: FF = Foliation fracture.
Small-scale roughness codes: P-R = Planar - rough, P-SM = Planar - smooth, U-R = Undulating - rough.
Aperture description codes: Open = Open (0.5mm - 2.5mm).

SUMMARY OF DISCONTINUITIES - RGM-BH7

Fracture Number	Depth (m)	Fracture Type	Dip (deg)	Small Scale Roughness	Aperture Description	Infill Material Description	Remarks	Stratigraphic Layer	Lithological Facies
17	8.68	FF	14	P-R	Open	Clean with iron staining and green		New Harbour Group	PSAMMITE
						discolouration			
18	10.17	FF	13	U-R	Open	Clean		New Harbour Group	PSAMMITE
19	10.30	FF	9	P-R	Open	Clean		New Harbour Group	PSAMMITE
20	10.70	FF	9	P-R	Open	Clean		New Harbour Group	PSAMMITE

Key:
Type codes: FF = Foliation fracture.
Small-scale roughness codes: P-R = Planar - rough, P-SM = Planar - smooth, U-R = Undulating - rough.
Aperture description codes: Open = Open (0.5mm - 2.5mm).

STRUCTURAL SOILS
The Old School
Stillhouse Lane
Bedminster
Bristol BS3 4EB

Compiled By	Date	Contract Ref:
DFAULKNER	30.1.15	728599

Contract: **Wylfa Newydd Detailed Onshore Ground Investigation**

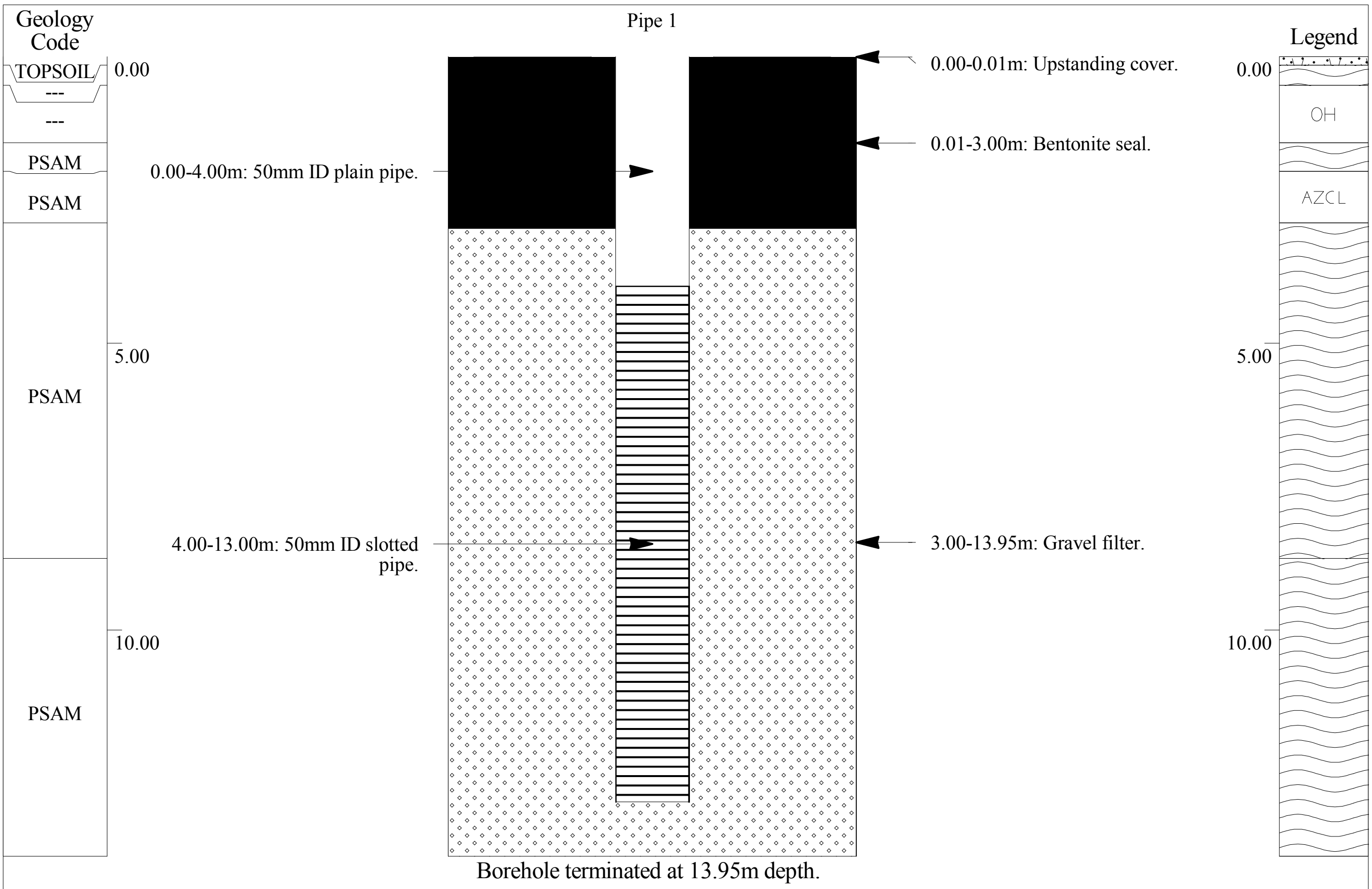
AGS

STRUCTURAL SOILS

[DI-126] - Issued to client for approval

INSTALLATION LOG

Contract:		Client:		Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation		Horizon Nuclear Power Wylfa Limited		RGM-BH7
Contract Ref: 728599	Start: 11.11.14 End: 12.11.14	Ground Level (m AOD): 24.65	National Grid Co-ordinate: E:234898.6 N:391949.7	Sheet: 1 of 2



General Remarks

Geology code details:

PSAM=PSAMMITE, TOPSOIL=Topsoil

1. Location CAT and Genny scanned prior to commencement.
2. Hand dug inspection pit GL to 0.60m depth.(IP)
3. Rotary open hole drilling from 0.60m to 1.50m depth and 2.00m to 2.90m depth on 11/11/2014.
4. Rotary cored drilling from 0.30m to 0.60m depth, 1.50m to 2.00m depth and 2.90m to 13.95m depth with water and air mist flush between

Note: Graphical representation of well installation is scaled vertically, but exaggerated in the horizontal to aid interpretation.

All dimensions in metres Scale 1:129	Installation Date 12/11/2015	Installation Type -	Installed By -

STRUCTURAL SOILS

INSTALLATION LOG

Contract:		Client:		Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation		Horizon Nuclear Power Wylfa Limited		RGM-BH7
Contract Ref: 728599	Start: 11.11.14 End: 12.11.14	Ground Level (m AOD): 24.65	National Grid Co-ordinate: E:234898.6 N:391949.7	Sheet: 2 of 2

Geology Code	Pipe 1	Legend

General Remarks

11/11/2014 and 12/11/2014.
5. Groundwater monitoring standpipe installed as shown upon completion.

Note: Graphical representation of well installation is scaled vertically, but exaggerated in the horizontal to aid interpretation.

All dimensions in metres Scale 1:129	Installation Date 12/11/2015	Installation Type -	Installed By -

[DI-126] - Issued to client for approval

STRUCTURAL SOILS

BOREHOLE LOG

Contract:	Client:	Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation	**Horizon Nuclear Power Wylfa Limited**	**RGM-BH13**

Contract Ref:	Start: / End:	Ground Level (m AOD):	National Grid Co-ordinate:	Sheet:
728599	Start: **18.11.14** End: **19.11.14**	**31.69**	**E:234648.2 N:391385.5**	**1** of **3**

Depth	TCR %	SCR %	RQD %	If (mm)	Flush Returns & Details	Drill Time (hh:mm:ss)	Description of Strata	Reduced Level	Depth (Thickness)
0.00							MADE GROUND: Asphalt. (Made Ground - MADE GROUND)	31.66	0.03
							MADE GROUND: Grey slightly sandy GRAVEL. (Made Ground - MADE GROUND)	31.49	0.20
							Firm locally friable red brown sandy CLAY with low cobble content. (Superficial Deposits - Locally derived lodgement till)	31.29	0.40
					Air+Mist (Grey)	(00:20:00)	Weak thinly banded grey slightly weathered PHYLLITE. (New Harbour Group - PHYLLITE)		
1.00									
						(0:05:00)			(2.87)
2.00					Air+Mist (Grey)	(00:30:00)			
					Air+Mist (Grey)	(00:45:00)			
3.00								28.42	3.27
					Air+Mist (Grey)	(0:20:00)	Medium strong narrowly banded very narrowly foliated light brownish grey and dark bluish grey fresh to slightly weathered PHYLLITE. (New Harbour Group - PHYLLITE)		
4.00				20 80 290					
						(0:25:00)			

Drilling Progress and Water Observations

Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
18/11/14	16:30	3.15	3.00	146	Dry
19/11/14	08:15	3.15	3.15	146	Dry
19/11/14	16:00	12.40	12.40	146	1.75

General Remarks

1. Location CAT and Genny scanned prior to commencement.
2. Hand dug inspection pit GL to 0.40m depth. (IP)
3. No groundwater encountered.
4. Rotary open hole drilling from 0.40m to 1.40m depth and 2.00m to 3.15m depth on 18/11/2014.
5. Rotary cored drilling from 1.40m to 2.00m depth and 3.15m to 12.40m depth with air mist flush between 18/11/2014 and 19/11/2014.

All dimensions in metres | Scale: **1:25** | Inclination: **Vertical** | Azimuth: **NA**

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary open hole + Rotary Cored	**Comacchio GEO 601**	**Scott Pincher**	**MHoness + WDixon**	**ADingle + ADingle + ADingle +**

STRUCTURAL SOILS

BOREHOLE LOG

Contract:	Client:	Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation	Horizon Nuclear Power Wylfa Limited	RGM-BH13

Contract Ref:	Start: 18.11.14	Ground Level (m AOD):	National Grid Co-ordinate:	Sheet:
728599	End: 19.11.14	31.69	E:234648.2 N:391385.5	2 of 3

Depth	TCR %	SCR %	RQD %	If (mm)	Flush Returns & Details	Drill Time (hh:mm:ss)	Sampling	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
				20 80 290	Air+Mist (Grey)	(0:25:00)							(2.50)	
5.00														
				100 100 840	Air+Mist (Grey)	(0:35:00)						25.92	5.77	
6.00										Medium strong very narrowly to narrowly banded very narrowly foliated purple and bluish green fresh PHYLLITE. (New Harbour Group - PHYLLITE)				
7.00					Air+Mist (Grey)	(0:42:00)								
8.00				320 780 1,100	Air+Mist (Grey)	(0:40:00)							(5.55)	

Drilling Progress and Water Observations					
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
18/11/14	16:30	3.15	3.00	146	Dry
19/11/14	08:15	3.15	3.15	146	Dry
19/11/14	16:00	12.40	12.40	146	1.75

General Remarks

6. Groundwater monitoring standpipe installed as shown upon completion.

All dimensions in metres | Scale: 1:25 | Inclination: Vertical | Azimuth: NA

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary open hole + Rotary Cored	Comacchio GEO 601	Scott Pincher	MHoness + WDixon	ADingle + ADingle + ADingle + ADingle

STRUCTURAL SOILS

BOREHOLE LOG

Contract:	Client:	Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation	Horizon Nuclear Power Wylfa Limited	RGM-BH13

Contract Ref:	Start: / End:	Ground Level (m AOD):	National Grid Co-ordinate:	Sheet:
728599	Start: 18.11.14 End: 19.11.14	31.69	E:234648.2 N:391385.5	3 of 3

Depth	TCR %	SCR %	RQD %	If (mm)	Flush Returns & Details	Drill Time (hh:mm:ss)	Sampling	Backfill & Instrumentation	Water	Description of Strata	Reduced Level	Depth (Thickness)
9.00 – 9.85					Air+Mist (Grey)	(0:40:00)						
9.85 – 11.40				320 / 780 / 1,100	Air+Mist (Grey)	(0:48:00)						
11.32										Medium strong to strong very narrowly to narrowly banded disturbed dark green fine grained fresh PSAMMITE with medium strong extremely closely to very closely spaced very narrow lenticular bands of very narrowly foliated brownish green PHYLLITE. (New Harbour Group - PSAMMITE)	20.37	11.32
11.40 – 12.40				40 / 160 / 530	Air+Mist (Grey)	(0:45:00)					19.29	(1.08) 12.40
12.40										Borehole terminated at 12.40m depth.		

Drilling Progress and Water Observations

Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
18/11/14	16:30	3.15	3.00	146	Dry
19/11/14	08:15	3.15	3.15	146	Dry
19/11/14	16:00	12.40	12.40	146	1.75

General Remarks

All dimensions in metres | Scale: 1:25 | Inclination: Vertical | Azimuth: NA

Method Used: Inspection pit + Rotary open hole + Rotary Cored | Plant Used: Comacchio GEO 601 | Drilled By: Scott Pincher | Logged By: MHoness + WDixon | Reviewed By: ADingle + ADingle + ADingle + ADingle

STRUCTURAL SOILS

[DI-126] - Issued to client for approval

BOREHOLE LOG

Contract:	Client:	Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation	Horizon Nuclear Power Wylfa Limited	RGM-BH13

Contract Ref:	Start: 18.11.14	Ground Level (m AOD):	National Grid Co-ordinate:	Sheet:
728599	End: 19.11.14	31.69	E:234648.2 N:391385.5	1 of 16

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
0.00						1A	EW				MADE GROUND: Asphalt. (Made Ground - MADE GROUND)		31.66	0.03	
0.00-0.40						IP1	D								
0.00-0.40						IP1	B				MADE GROUND: Grey slightly sandy GRAVEL. Gravel is angular to subangular fine to medium psammite. Sand is fine to coarse. (Made Ground - MADE GROUND)		31.49	(0.17) 0.20	
0.00-0.40						RAD1	D								
											Firm locally friable red brown sandy CLAY with low cobble content. Gravel is angular tabular fine to coarse phyllite. Cobbles are angular cubic phyllite. Sand is fine to coarse. (Superficial Deposits - Locally derived lodgement till)		31.29	(0.20) 0.40	
					Air+Mist (Grey)						Weak thinly banded grey slightly weathered PHYLLITE. (New Harbour Group - PHYLLITE)		31		

Drilling Progress and Water Observations

Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
18/11/14	16:30	3.15	3.00	146	Dry
19/11/14	08:15	3.15	3.15	146	Dry
19/11/14	16:00	12.40	12.40	146	1.75

General Remarks

1. Location CAT and Genny scanned prior to commencement.
2. Hand dug inspection pit GL to 0.40m depth. (IP)
3. No groundwater encountered.
4. Rotary open hole drilling from 0.40m to 1.40m depth and 2.00m to 3.15m depth on 18/11/2014.
5. Rotary cored drilling from 1.40m to 2.00m depth and 3.15m to 12.40m depth with air mist flush between 18/11/2014 and 19/11/2014.

All dimensions in metres | Scale: 1:5 | Inclination: Vertical | Azimuth: NA

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary open hole + Rotary Cored	Comacchio GEO 601	Scott Pincher	MHoness + WDixon	ADingle + ADingle + ADingle +

STRUCTURAL SOILS

BOREHOLE LOG

Contract:	Client:	Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation	**Horizon Nuclear Power Wylfa Limited**	**RGM-BH13**

Contract Ref:	Start: / End:	Ground Level (m AOD):	National Grid Co-ordinate:	Sheet:
728599	Start: **18.11.14** End: **19.11.14**	**31.69**	**E:234648.2 N:391385.5**	**2** of **16**

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instru-mentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
					Air+Mist (Grey)									1	
1.40-2.00 (0:05)	0	0	0										30		

Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
18/11/14	16:30	3.15	3.00	146	Dry
19/11/14	08:15	3.15	3.15	146	Dry
19/11/14	16:00	12.40	12.40	146	1.75

Drilling Progress and Water Observations

General Remarks

6. Groundwater monitoring standpipe installed as shown upon completion.

All dimensions in metres | Scale: **1:5** | Inclination: **Vertical** | Azimuth: **NA**

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary open hole + Rotary Cored	**Comacchio GEO 601**	**Scott Pincher**	**MHoness + WDixon**	**ADingle + ADingle + ADingle +**

STRUCTURAL SOILS

BOREHOLE LOG

Contract: Wylfa Newydd Detailed Onshore Ground Investigation		Client: Horizon Nuclear Power Wylfa Limited		Borehole: RGM-BH13
Contract Ref: 728599	Start: 18.11.14 End: 19.11.14	Ground Level (m AOD): 31.69	National Grid Co-ordinate: E:234648.2 N:391385.5	Sheet: 3 of 16

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
	0	0	0											(2.87)	
					Air+Mist (Grey)									2	
					Air+Mist (Grey)								29		

Drilling Progress and Water Observations					
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
18/11/14	16:30	3.15	3.00	146	Dry
19/11/14	08:15	3.15	3.15	146	Dry
19/11/14	16:00	12.40	12.40	146	1.75

General Remarks

All dimensions in metres | Scale: 1:5 | Inclination: Vertical | Azimuth: NA

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary open hole + Rotary Cored	Comacchio GEO 601	Scott Pincher	MHoness + WDixon	ADingle + ADingle + ADingle +

[DI-126] - Issued to client for approval

STRUCTURAL SOILS

BOREHOLE LOG

Contract:	Client:	Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation	**Horizon Nuclear Power Wylfa Limited**	**RGM-BH13**

Contract Ref:	Start:	Ground Level (m AOD):	National Grid Co-ordinate:	Sheet:
728599	**18.11.14** / End: **19.11.14**	**31.69**	**E:234648.2 N:391385.5**	**4** of **16**

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
					Air+Mist (Grey)								28.42	3 / 3.27	
3.27-4.11 (0:20)	100	100	100	20 80 290	Air+Mist (Grey)						Medium strong narrowly banded very narrowly foliated light brownish grey and dark bluish grey fresh to slightly weathered PHYLLITE. Foliation is shallowly dipping. Joints are shallowly to steeply dipping locally extremely closely to medium spaced planar smooth to rough rarely partly open to open clean or containing dark brown staining on fracture surface and quartz infill in possible re-fused micro-faults. (New Harbour Group - PHYLLITE)	1 IcF[i]			

Drilling Progress and Water Observations

Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
18/11/14	16:30	3.15	3.00	146	Dry
19/11/14	08:15	3.15	3.15	146	Dry
19/11/14	16:00	12.40	12.40	146	1.75

General Remarks

28

All dimensions in metres | Scale: **1:5** | Inclination: **Vertical** | Azimuth: **NA**

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary open hole + Rotary Cored	**Comacchio GEO 601**	**Scott Pincher**	**MHoness + WDixon**	**ADingle + ADingle + ADingle +**

STRUCTURAL SOILS

BOREHOLE LOG

Contract:	Client:	Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation	Horizon Nuclear Power Wylfa Limited	RGM-BH13

Contract Ref:	Start / End	Ground Level (m AOD):	National Grid Co-ordinate:	Sheet:
728599	Start: 18.11.14 End: 19.11.14	31.69	E:234648.2 N:391385.5	5 of 16

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
	100	100	100	20 80 290	Air+Mist (Grey)							$2_{IcF[i]}$ $3_{J[i]}$ $4_{J[i]}$ $5_{IcF[i]}$	28	4	
4.11-5.26 (0:25)	100	100	80		Air+Mist (Grey)							$6_{J[i]}$			

Drilling Progress and Water Observations

Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
18/11/14	16:30	3.15	3.00	146	Dry
19/11/14	08:15	3.15	3.15	146	Dry
19/11/14	16:00	12.40	12.40	146	1.75

General Remarks

All dimensions in metres | Scale: 1:5 | Inclination: Vertical | Azimuth: NA

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary open hole + Rotary Cored	Comacchio GEO 601	Scott Pincher	MHoness + WDixon	ADingle + ADingle + ADingle +

STRUCTURAL SOILS

BOREHOLE LOG

Contract: Wylfa Newydd Detailed Onshore Ground Investigation		Client: Horizon Nuclear Power Wylfa Limited		Borehole: RGM-BH13
Contract Ref: 728599	Start: 18.11.14 End: 19.11.14	Ground Level (m AOD): 31.69	National Grid Co-ordinate: E:234648.2 N:391385.5	Sheet: 6 of 16

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
												7 J[i]		(2.50)	
											4.68-4.70m : Possible re-fused micro-fault with 6mm lateral offset of intersected phyllite bands.	8 J[i], 9 J[i], 10 J[i]	27		
	100	100	80	20 80 290	Air+Mist (Grey)							11 IcF[i]			
											5.04m : Possible re-fused micro-fault with 9mm lateral offset of intersected phyllite bands. 5.07m : Shallowly dipping very narrow band of vugs with quartz infill intersecting shallowly dipping chlorite micro-veins.	12 J[i], 13 J[i], 14 J[i]		5	
5.26-6.83 (0:35)	100	100	100	100 100 840	Air+Mist (Grey)						5.28-5.45m : Shallowly dipping very narrow lenticular quartz veins.				

Drilling Progress and Water Observations

Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
18/11/14	16:30	3.15	3.00	146	Dry
19/11/14	08:15	3.15	3.15	146	Dry
19/11/14	16:00	12.40	12.40	146	1.75

General Remarks

All dimensions in metres | Scale: 1:5 | Inclination: Vertical | Azimuth: NA

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary open hole + Rotary Cored	Comacchio GEO 601	Scott Pincher	MHoness + WDixon	ADingle + ADingle + ADingle +

STRUCTURAL SOILS

[DI-126] - Issued to client for approval

BOREHOLE LOG

Contract:	Client:	Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation	Horizon Nuclear Power Wylfa Limited	RGM-BH13

Contract Ref:	Start: 18.11.14 / End: 19.11.14	Ground Level (m AOD):	National Grid Co-ordinate:	Sheet:
728599		31.69	E:234648.2 N:391385.5	7 of 16

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)
											5.47-5.57m : Thin shallowly dipping band of very narrow disturbed light brownish yellow and dark green chlorite veins intersected by shallowly dipping very narrow quartz veins.		26	
													25.92	5.77
	100	100	100	100 100 840	Air+Mist (Grey)						Medium strong very narrowly to narrowly banded very narrowly foliated purple and bluish green fresh PHYLLITE. Foliation is sub-horizontal to shallowly dipping. Occasional localised shallowly dipping very narrow to narrow calcite and quartz veins. Foliation fractures are shallowly dipping medium spaced planar smooth open clean. Joints are shallowly to steeply dipping extremely closely to medium spaced planar smooth to rough partly open to open clean to containing dark brown staining on fracture surface quartz and calcite infill. (New Harbour Group - PHYLLITE)	15 IcF[i] 16 IcF[i] 17 J[i]		6

Drilling Progress and Water Observations

Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
18/11/14	16:30	3.15	3.00	146	Dry
19/11/14	08:15	3.15	3.15	146	Dry
19/11/14	16:00	12.40	12.40	146	1.75

General Remarks

All dimensions in metres | Scale: 1:5 | Inclination: Vertical | Azimuth: NA

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary open hole + Rotary Cored	Comacchio GEO 601	Scott Pincher	MHoness + WDixon	ADingle + ADingle + ADingle +

STRUCTURAL SOILS

BOREHOLE LOG

Contract:	Client:	Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation	Horizon Nuclear Power Wylfa Limited	RGM-BH13

Contract Ref:	Start: 18.11.14	Ground Level (m AOD):	National Grid Co-ordinate:	Sheet:
728599	End: 19.11.14	31.69	E:234648.2 N:391385.5	8 of 16

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
	100	100	100	100 100 840	Air+Mist (Grey)							18 J[i]	25		
6.83-8.27 (0:42)	100	100	100		Air+Mist (Grey)						7.11m : Sub-horizontal band of subangular medium patches of calcite. 7.13-7.77m : Steeply dipping to sub-vertical very narrow lenticular calcite tension veins.			7	

Drilling Progress and Water Observations					
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
18/11/14	16:30	3.15	3.00	146	Dry
19/11/14	08:15	3.15	3.15	146	Dry
19/11/14	16:00	12.40	12.40	146	1.75

General Remarks

All dimensions in metres | Scale: 1:5 | Inclination: Vertical | Azimuth: NA

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary open hole + Rotary Cored	Comacchio GEO 601	Scott Pincher	MHoness + WDixon	ADingle + ADingle + ADingle +

STRUCTURAL SOILS

[DI-126] - Issued to client for approval

BOREHOLE LOG

Contract: Wylfa Newydd Detailed Onshore Ground Investigation	Client: Horizon Nuclear Power Wylfa Limited	Borehole: RGM-BH13
Contract Ref: 728599 / Start: 18.11.14 End: 19.11.14 / Ground Level (m AOD): 31.69	National Grid Co-ordinate: E:234648.2 N:391385.5	Sheet: 9 of 16

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
	100	100	100	100 100 840	Air+Mist (Grey)						7.67m : Possible re-fused micro-fault with 5mm lateral offset of intersected phyllite bands.	19 J[i], 20 J[i], 21 J[i], 22 J[i]	24	8	

Drilling Progress and Water Observations

Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
18/11/14	16:30	3.15	3.00	146	Dry
19/11/14	08:15	3.15	3.15	146	Dry
19/11/14	16:00	12.40	12.40	146	1.75

General Remarks

All dimensions in metres | Scale: 1:5 | Inclination: Vertical | Azimuth: NA

Method Used: Inspection pit + Rotary open hole + Rotary Cored | Plant Used: Comacchio GEO 601 | Drilled By: Scott Pincher | Logged By: MHoness + WDixon | Reviewed By: ADingle + ADingle + ADingle +

STRUCTURAL SOILS

[DI-126] - Issued to client for approval

BOREHOLE LOG

Contract:	Client:	Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation	**Horizon Nuclear Power Wylfa Limited**	**RGM-BH13**

Contract Ref:	Start / End	Ground Level (m AOD):	National Grid Co-ordinate:	Sheet:
728599	Start: **18.11.14** End: **19.11.14**	**31.69**	**E:234648.2 N:391385.5**	**10** of **16**

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
	100	100	100		Air+Mist (Grey)						8.22-8.63m : Sub-vertical very narrow calcite vein.				
8.27-9.85 (0:40)	100	100	100	320 780 1,100	Air+Mist (Grey)						8.43m : Sub-vertical very narrow calcite vein intersected by sub-vertical calcite vein causing 9mm lateral offset. 8.48m : Sub-horizontal narrow disturbed light brownish yellow bands of phyllite and fine to medium patches of calcite. 8.63-8.68m : Subangular coarse patch of calcite terminating against sub-horizontal very narrow bands of chlorite and medium patches of calcite. 8.80-9.04m : Sub-horizontal very narrow closely spaced calcite veins possibly infilling very narrow chlorite veins.		23	(5.55)	

9

Drilling Progress and Water Observations					
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
18/11/14	16:30	3.15	3.00	146	Dry
19/11/14	08:15	3.15	3.15	146	Dry
19/11/14	16:00	12.40	12.40	146	1.75

General Remarks

All dimensions in metres | Scale: **1:5** | Inclination: **Vertical** | Azimuth: **NA**

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary open hole + Rotary Cored	**Comacchio GEO 601**	**Scott Pincher**	**MHoness + WDixon**	**ADingle + ADingle + ADingle +**

STRUCTURAL SOILS

BOREHOLE LOG

Contract:	Client:	Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation	Horizon Nuclear Power Wylfa Limited	RGM-BH13

Contract Ref:	Start: 18.11.14	Ground Level (m AOD):	National Grid Co-ordinate:	Sheet:
728599	End: 19.11.14	31.69	E:234648.2 N:391385.5	11 of 16

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
												23 FF[i]			
	100	100	100	320 780 1,100	Air+Mist (Grey)							24 FF[i]			
											9.53m : Subangular coarse patch of calcite and chlorite intersected by steeply dipping very narrow calcite vein. 9.55-9.85m : Sub-horizontal very narrow disturbed patches of calcite.				
													22		
9.85-11.40 (0:48)	100	100	100												

Drilling Progress and Water Observations

Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
18/11/14	16:30	3.15	3.00	146	Dry
19/11/14	08:15	3.15	3.15	146	Dry
19/11/14	16:00	12.40	12.40	146	1.75

General Remarks

All dimensions in metres | Scale: 1:5 | Inclination: Vertical | Azimuth: NA

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary open hole + Rotary Cored	Comacchio GEO 601	Scott Pincher	MHoness + WDixon	ADingle + ADingle + ADingle +

STRUCTURAL SOILS

BOREHOLE LOG

Contract: Wylfa Newydd Detailed Onshore Ground Investigation		Client: Horizon Nuclear Power Wylfa Limited		Borehole: RGM-BH13
Contract Ref: 728599	Start: 18.11.14 End: 19.11.14	Ground Level (m AOD): 31.69	National Grid Co-ordinate: E:234648.2 N:391385.5	Sheet: 12 of 16

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
														10	
											10.07-10.13m : Shallowly dipping very narrow extremely closely to very closely spaced quartz veins.	25 IcF[i]			
											10.15m : Sub-horizontal very thin band of subangular medium to coarse patches of quartz and chlorite.				
	100	100	100	320 780 1,100	Air+Mist (Grey)						10.32-10.67m : Shallowly dipping very narrow to narrow ptygmatic extremely closely to closely spaced quartz veins with rare subangular fine patches of chlorite.				
													21		

Drilling Progress and Water Observations					
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
18/11/14	16:30	3.15	3.00	146	Dry
19/11/14	08:15	3.15	3.15	146	Dry
19/11/14	16:00	12.40	12.40	146	1.75

General Remarks

All dimensions in metres | Scale: 1:5 | Inclination: Vertical | Azimuth: NA

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary open hole + Rotary Cored	Comacchio GEO 601	Scott Pincher	MHoness + WDixon	ADingle + ADingle + ADingle +

STRUCTURAL SOILS

BOREHOLE LOG

Contract:	Client:	Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation	Horizon Nuclear Power Wylfa Limited	RGM-BH13

Contract Ref:	Start: 18.11.14	Ground Level (m AOD):	National Grid Co-ordinate:	Sheet:
728599	End: 19.11.14	31.69	E:234648.2 N:391385.5	13 of 16

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
	100	100	100	320 780 1,100	Air+Mist (Grey)						11.24m : Shallowly dipping narrow band of medium patches of quartz.	26 IcF[i] 27 IcF[i]	20.37	11 11.32	
11.40-12.40 (0:45)	93	93	93	40 160 530	Air+Mist (Grey)						Medium strong to strong very narrowly to narrowly banded disturbed dark green fine grained fresh PSAMMITE with medium strong extremely closely to very closely spaced very narrow lenticular bands of very narrowly foliated brownish green PHYLLITE. Foliation is sub-horizontal and disturbed. Frequent subangular to subrounded medium to coarse patches of quartz with rare medium patches of possible epidote. Joints are shallowly dipping medium spaced planar rough open clean. (New Harbour Group - PSAMMITE) 11.61-11.75m : Subangular coarse gravel sized disturbed patches of quartz.		20		

Drilling Progress and Water Observations

Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
18/11/14	16:30	3.15	3.00	146	Dry
19/11/14	08:15	3.15	3.15	146	Dry
19/11/14	16:00	12.40	12.40	146	1.75

General Remarks

All dimensions in metres | Scale: 1:5 | Inclination: Vertical | Azimuth: NA

Method Used:	Plant Used:	Drilled By:	Logged By:	Reviewed By:
Inspection pit + Rotary open hole + Rotary Cored	Comacchio GEO 601	Scott Pincher	MHoness + WDixon	ADingle + ADingle + ADingle +

[DI-126] - Issued to client for approval

STRUCTURAL SOILS

BOREHOLE LOG

Contract: Wylfa Newydd Detailed Onshore Ground Investigation	Client: Horizon Nuclear Power Wylfa Limited	Borehole: RGM-BH13
Contract Ref: 728599	Start: 18.11.14 End: 19.11.14	Ground Level (m AOD): 31.69	National Grid Co-ordinate: E:234648.2 N:391385.5	Sheet: 14 of 16

Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	Flush Returns & Details	No	Type	Results	Backfill & Instrumentation	Water	Description of Strata	Fracture Log	Reduced Level	Depth (Thickness)	Material Graphic Legend
				40 160 530								28 J[i] 29 IcF[i]		(1.08)	
12	93	93	93		Air+Mist (Grey)						12.00m : Circular narrow quartz vein with occasional subangular medium gravel sized chlorite patches. 12.01-12.08m : Subrounded medium to coarse patches of quartz with rare possible medium patches of epidote. 12.08-12.33m : Abundant subrounded coarse gravel sized patches of quartz engulfing main composition of rock.	30 J[i]			
													19.29	12.40	
											Borehole terminated at 12.40m depth.				

Drilling Progress and Water Observations					
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth
18/11/14	16:30	3.15	3.00	146	Dry
19/11/14	08:15	3.15	3.15	146	Dry
19/11/14	16:00	12.40	12.40	146	1.75

General Remarks

All dimensions in metres | Scale: 1:5 | Inclination: Vertical | Azimuth: NA

Method Used: Inspection pit + Rotary open hole + Rotary Cored	Plant Used: Comacchio GEO 601	Drilled By: Scott Pincher	Logged By: MHoness + WDixon	Reviewed By: ADingle + ADingle + ADingle +

STRUCTURAL SOILS

BOREHOLE LOG

Contract: Wylfa Newydd Detailed Onshore Ground Investigation			Client: Horizon Nuclear Power Wylfa Limited		Borehole: RGM-BH13
Contract Ref: 728599	Start: 18.11.14	End: 19.11.14	Ground Level (m AOD): 31.69	National Grid Co-ordinate: E:234648.2 N:391385.5	Sheet: 15 of 16

RGM-BH13 Box 1-2 3.15m - 5.20m depth

RGM-BH13 Box 3-4 5.20m - 8.40m depth

Method Used: Inspection pit + Rotary open hole + Rotary Cored	Plant Used: Comacchio GEO 601	Drilled By: Scott Pincher	Logged By: MHoness + WDixon	Reviewed By: ADingle + ADingle + ADingle + ADingle

[DI-126] - Issued to client for approval

STRUCTURAL SOILS

BOREHOLE LOG

Contract:			Client:	Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation			Horizon Nuclear Power Wylfa Limited	RGM-BH13
Contract Ref: 728599	Start: 18.11.14 End: 19.11.14	Ground Level (m AOD): 31.69	National Grid Co-ordinate: E:234648.2 N:391385.5	Sheet: 16 of 16

RGM-BH13 Box 5-6 8.40m - 11.40m depth

RGM-BH13 Box 7 11.40m - 12.40m depth

Method Used:	Inspection pit + Rotary open hole + Rotary Cored	Plant Used:	Comacchio GEO 601	Drilled By:	Scott Pincher	Logged By:	MHoness + WDixon	Reviewed By:	ADingle + ADingle + ADingle + ADingle

SUMMARY OF DISCONTINUITIES - RGM-BH13

Fracture Number	Depth (m)	Fracture Type	Dip (deg)	Small Scale Roughness	Aperture Description	Infill Material Description	Remarks	Stratigraphic Layer	Lithological Facies
1	3.55	IcF	35	-	Partly open	Brown staining on fracture surface		New Harbour Group	PHYLLITE
2	3.68	IcF	49	-	Partly open	Brown staining on fracture surface		New Harbour Group	PHYLLITE
3	3.83	J	44	U-R	Partly open	Brown staining on fracture surface		New Harbour Group	PHYLLITE
4	3.93	J	58	U-R	Open	Brown staining on fracture surface		New Harbour Group	PHYLLITE
5	4.08	IcF	58	-	Open	Brown staining on fracture surface		New Harbour Group	PHYLLITE
6	4.37	J	50	P-R	Open	Dark brown staining on fracture surface		New Harbour Group	PHYLLITE
7	4.55	J	50	P-SM	Open	Brown staining on fracture surface		New Harbour Group	PHYLLITE
8	4.65	J	46	P-SM	Open	Brown staining on fracture surface		New Harbour Group	PHYLLITE
9	4.68	J	48	U-R	Partly open	Quartz infill	Possible re-fused micro-fault due to 6mm lateral	New Harbour Group	PHYLLITE
							offset of intersected phyllite bands.		
10	4.70	J	57	U-R	Open	Quartz infill	Possible re-fused micro-fault due to 6mm lateral	New Harbour Group	PHYLLITE
							offset of intersected phyllite bands.		
11	4.77	IcF	73	-	Open	Dark brown staining on fracture		New Harbour Group	PHYLLITE
12	4.93	J	78	U-R	Open	Dark brown staining on fracture surface		New Harbour Group	PHYLLITE
13	4.97	J	51	P-R	Open	Brown staining on fracture surface		New Harbour Group	PHYLLITE
14	5.04	J	45	P-SM	Partly open	Quartz infill	Possible re-fused micro-fault due to 9mm lateral	New Harbour Group	PHYLLITE

Key:
Type codes: FF = Foliation fracture, IcF = Incipient fracture, J = Joint.
Small-scale roughness codes: P-R = Planar - rough, P-SM = Planar - smooth, U-R = Undulating - rough.
Aperture description codes: Open = Open (0.5mm - 2.5mm), Partly open = Partly open (0.25mm - 0.5mm).

SUMMARY OF DISCONTINUITIES - RGM-BH13

Fracture Number	Depth (m)	Fracture Type	Dip (deg)	Small Scale Roughness	Aperture Description	Infill Material Description	Remarks	Stratigraphic Layer	Lithological Facies
							offset of intersected phyllite bands.		
15	5.88	IcF	83	-	Open	Chlorite infill		New Harbour Group	PHYLLITE
16	6.15	IcF	86	-	Open	Dark brown staining on fracture surface		New Harbour Group	PHYLLITE
17	6.25	J	43	P-SM	Open	Dark brown staining on fracture surface		New Harbour Group	PHYLLITE
18	6.71	J	48	P-R	Open	Calcite infill		New Harbour Group	PHYLLITE
19	7.38	J	49	P-R	Open	No infill		New Harbour Group	PHYLLITE
20	7.57	J	49	P-SM	Open	No infill		New Harbour Group	PHYLLITE
21	7.67	J	53	P-SM	Partly open	Calcite infill	Possible re-fused micro-fault due to 5mm lateral	New Harbour Group	PHYLLITE
							offset of intersected phyllite bands.		
22	8.08	J	43	P-SM	Open	No infill	Narrow band of calcite on edge of joint	New Harbour Group	PHYLLITE
23	9.11	FF	16	P-SM	Open	No infill		New Harbour Group	PHYLLITE
24	9.43	FF	18	P-SM	Open	No infill		New Harbour Group	PHYLLITE
25	10.10	IcF	47	-	Open	Calcite infill	Incipient fracture is 'branched'	New Harbour Group	PHYLLITE
26	11.20	IcF	88	-	Partly open	No infill		New Harbour Group	PHYLLITE
27	11.25	IcF	87	-	Partly open	No infill		New Harbour Group	PHYLLITE
28	11.79	J	23	P-R	Open	No infill		New Harbour Group	PSAMMITE

Key:
Type codes: FF = Foliation fracture, IcF = Incipient fracture, J = Joint.
Small-scale roughness codes: P-R = Planar - rough, P-SM = Planar - smooth, U-R = Undulating - rough.
Aperture description codes: Open = Open (0.5mm - 2.5mm), Partly open = Partly open (0.25mm - 0.5mm).

SUMMARY OF DISCONTINUITIES - RGM-BH13

Fracture Number	Depth (m)	Fracture Type	Dip (deg)	Small Scale Roughness	Aperture Description	Infill Material Description	Remarks	Stratigraphic Layer	Lithological Facies
29	11.83	IcF	79	-	Open	Calcite infill		New Harbour Group	PSAMMITE
30	12.14	J	19	P-R	Open	No infill		New Harbour Group	PSAMMITE

Key:
Type codes: FF = Foliation fracture, IcF = Incipient fracture, J = Joint.
Small-scale roughness codes: P-R = Planar - rough, P-SM = Planar - smooth, U-R = Undulating - rough.
Aperture description codes: Open = Open (0.5mm - 2.5mm), Partly open = Partly open (0.25mm - 0.5mm).

STRUCTURAL SOILS
The Old School
Stillhouse Lane
Bedminster
Bristol BS3 4EB

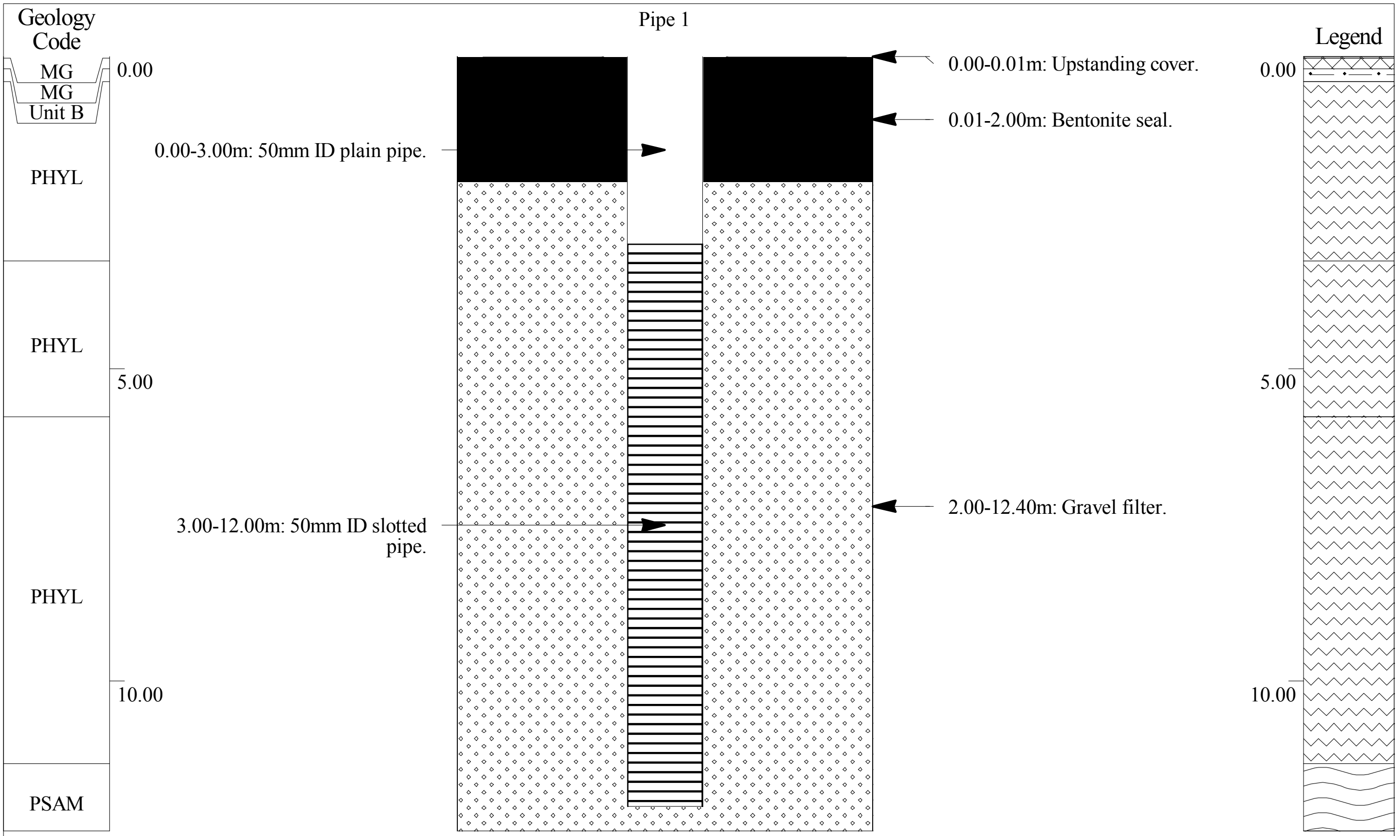
Compiled By		Date	Contract Ref:
[redacted]	JTAYLOR	29.1.15	728599

Contract: **Wylfa Newydd Detailed Onshore Ground Investigation**

STRUCTURAL SOILS

INSTALLATION LOG

Contract:		Client:		Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation		Horizon Nuclear Power Wylfa Limited		RGM-BH13
Contract Ref: 728599	Start: 18.11.14 End: 19.11.14	Ground Level (m AOD): 31.69	National Grid Co-ordinate: E:234648.2 N:391385.5	Sheet: 1 of 2



Borehole terminated at 12.40m depth.

General Remarks

Geology code details:

MG=MADE GROUND, PHYL=PHYLLITE, PSAM=PSAMMITE, Unit B=Locally derived lodgement till

1. Location CAT and Genny scanned prior to commencement.
2. Hand dug inspection pit GL to 0.40m depth. (IP)
3. No groundwater encountered.
4. Rotary open hole drilling from 0.40m to 1.40m depth and 2.00m to 3.15m depth on 18/11/2014.

Note: Graphical representation of well installation is scaled vertically, but exaggerated in the horizontal to aid interpretation.

All dimensions in metres Scale 1:121	Installation Date -	Installation Type -	Installed By -

[DI-126] - Issued to client for approval

STRUCTURAL SOILS

INSTALLATION LOG

Contract:		Client:		Borehole:
Wylfa Newydd Detailed Onshore Ground Investigation		Horizon Nuclear Power Wylfa Limited		RGM-BH13
Contract Ref: 728599	Start: 18.11.14 End: 19.11.14	Ground Level (m AOD): 31.69	National Grid Co-ordinate: E:234648.2 N:391385.5	Sheet: 2 of 2

Geology Code | Pipe 1 | Legend

General Remarks

5. Rotary cored drilling from 1.40m to 2.00m depth and 3.15m to 12.40m depth with air mist flush between 18/11/2014 and 19/11/2014.
6. Groundwater monitoring standpipe installed as shown upon completion.

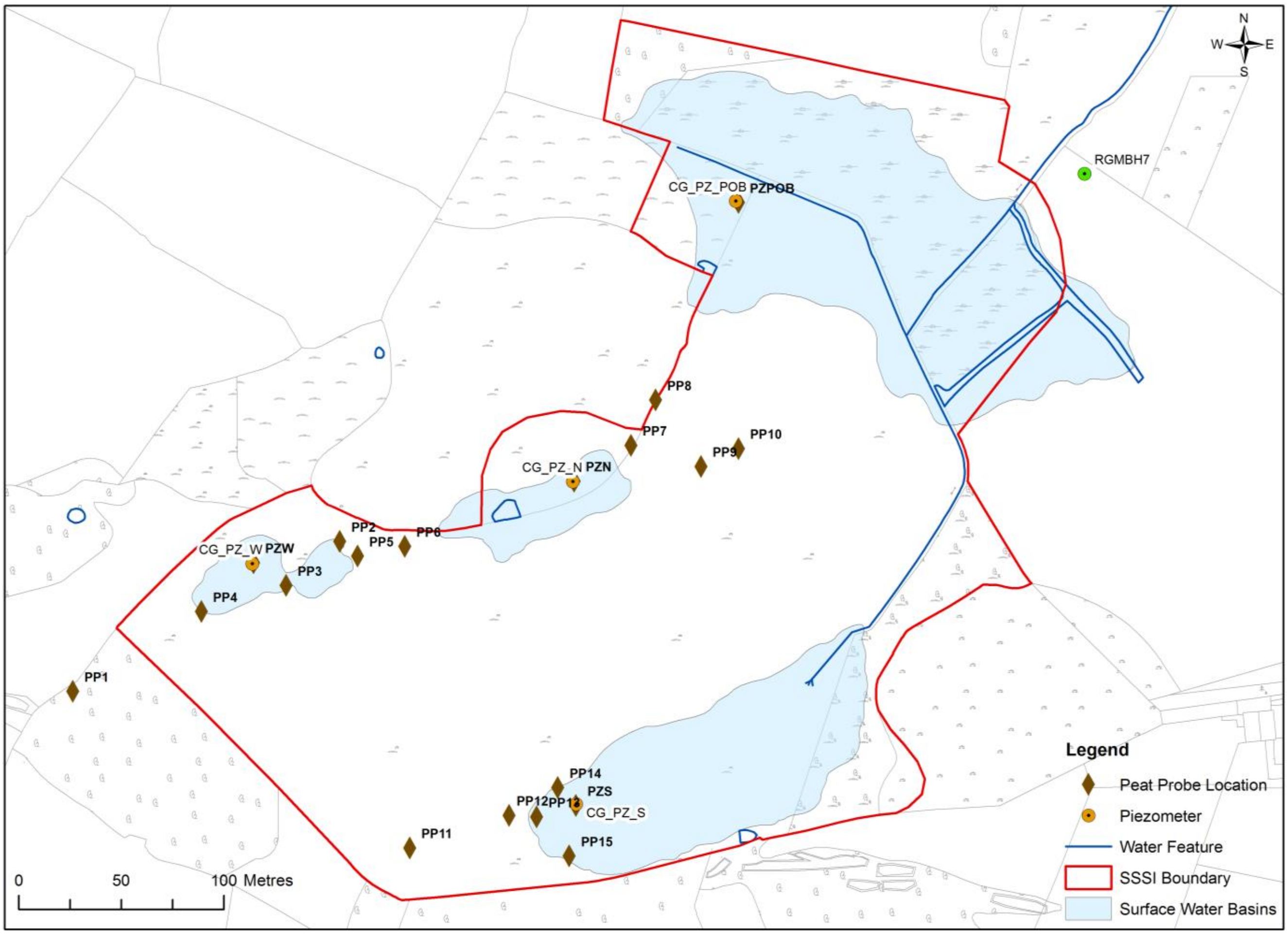
Note: Graphical representation of well installation is scaled vertically, but exaggerated in the horizontal to aid interpretation.

All dimensions in metres	Installation Date	Installation Type	Installed By
Scale 1:121	-	-	-

Annex C. Peat / soil probing and coring results

Annex C. Peat/soil probing and coring results

CORE/PROBE ID	EASTING	NORTHING	LOCATION	GROUND LEVEL	BEDROCK LEVEL	PEAT DEPTH
				MAOD	MAOD	M
PP1	234405.08	391697.83	-	23.83	23.51	0.32
PP2	234534.71	391770.97	FAR EASTERN EDGE OF WB	25.37	25.17	0.2
PP3	234508.65	391748.98	WB	24.88	24.65	0.225
PP4	234467.58	391735.60	FAR WESTERN EDGE OF WB	24.81	24.71	0.1
PP5	234544.46	391763.13	FAR EASTERN EDGE OF WB	25.54	25.40	0.14
PP6	234567.05	391768.89	-	26.35	25.90	0.45
PP7	234676.75	391822.14	-	25.72	25.60	0.115
PP8	234685.67	391837.62	-	25.59	25.47	0.12
PP9	234710.68	391807.20	-	25.79	25.60	0.19
PP10	234728.92	391816.27	-	25.58	25.50	0.08
PP11	234570.05	391621.45	-	29.72	29.55	0.17
PP12	234617.01	391637.42	-	28.41	28.18	0.23
PP13	234630.67	391635.94	WESTERN EDGE OF SB	28.07	27.84	0.23
PP14	234642.43	391651.49	WESTERN EDGE OF SB	28.10	27.45	0.65
PP15	234647.01	391617.48	SOUTHWESTERN EDGE OF SB	28.06	27.61	0.45
CG_PZ_S	234650.75	391642.69	SOUTHERN BASIN	27.82	26.93	1.20
CG_PZ_W	234492.82	391759.75	WESTERN BASIN	24.62	24.35	0.40
CG_PZ_N	234649.09	391799.73	NORTHERN BASIN	25.61	25.47	0.26
CG_PZ_POB	234728.51	391936.34	POB	22.88	21.32	1.75



N
W
E
S
RGMBH7
CG_PZ_POB
PZPOB
PP8
PP7
PP10
PP9
CG_PZ_N
PZN
PP2
PP5
PP6
CG_PZ_W
PZW
PP3
PP4
PP1
PP14
PZS
PP12
PP13
CG_PZ_S
PP11
PP15
0
50
100 Metres
Legend
Peat Probe Location
Piezometer
Water Feature
SSSI Boundary
Surface Water Basins

Annex D. Piezometer details

Core/Piezometer ID	NGR Easting	NGR Northing	Elevation (mAOD)	Photo ID (s)
CG_PZ_S	234651	391643	27.82	-
Core Depth (m)	**Peat Depth (m)**	**Water table Depth (m)**	**Acrotelm Depth (m)**	**Catotelm Depth (m)**
1.2	1.2	Ground surface	No distinct acrotelm/catotelm layers	-
Von Post H Scores		**Von Post B Scores**		**Piezometer Installation Depth (m)**
Acrotelm	***Catotelm***	***Acrotelm***	***Catotelm***	
-	**-**	**-**	**-**	**-**

General Comments:

Regarding saturation of peat, type of substrate, presence of silt/sand in peat, vegetation, ease of piezometer installation, any issues with installation.

Saturated peat, poor core recovery

Core/Piezometer ID	**NGR Easting**	**NGR Northing**	**Elevation (mAOD)**	**Photo ID (s)**
CG_PZ_W	234493	391760	24.62	-
Core Depth (m)	**Peat Depth (m)**	**Water table Depth (m)**	**Acrotelm Depth (m)**	**Catotelm Depth (m)**
0.4	Mineral soil	-	-	-
Von Post H Scores		**Von Post B Scores**		**Piezometer Installation Depth (m)**
Acrotelm	***Catotelm***	***Acrotelm***	***Catotelm***	
-	**-**	**-**	**-**	**-**
General Comments: **Regarding saturation of peat, type of substrate, presence of silt/sand in peat, vegetation, ease of piezometer installation, any issues with installation.**				
				

Core/Piezometer ID	NGR Easting	NGR Northing	Elevation (mAOD)	Photo ID (s)
CG_PZ_N	234649	391800	25.47	-
Core Depth (m)	**Peat Depth (m)**	**Water table Depth (m)**	**Acrotelm Depth (m)**	**Catotelm Depth (m)**
0.26	Mineral soil	-	-	-
Von Post H Scores		**Von Post B Scores**		**Piezometer Installation Depth (m)**
Acrotelm	***Catotelm***	***Acrotelm***	***Catotelm***	
-	**-**	**-**	**-**	**-**

General Comments:

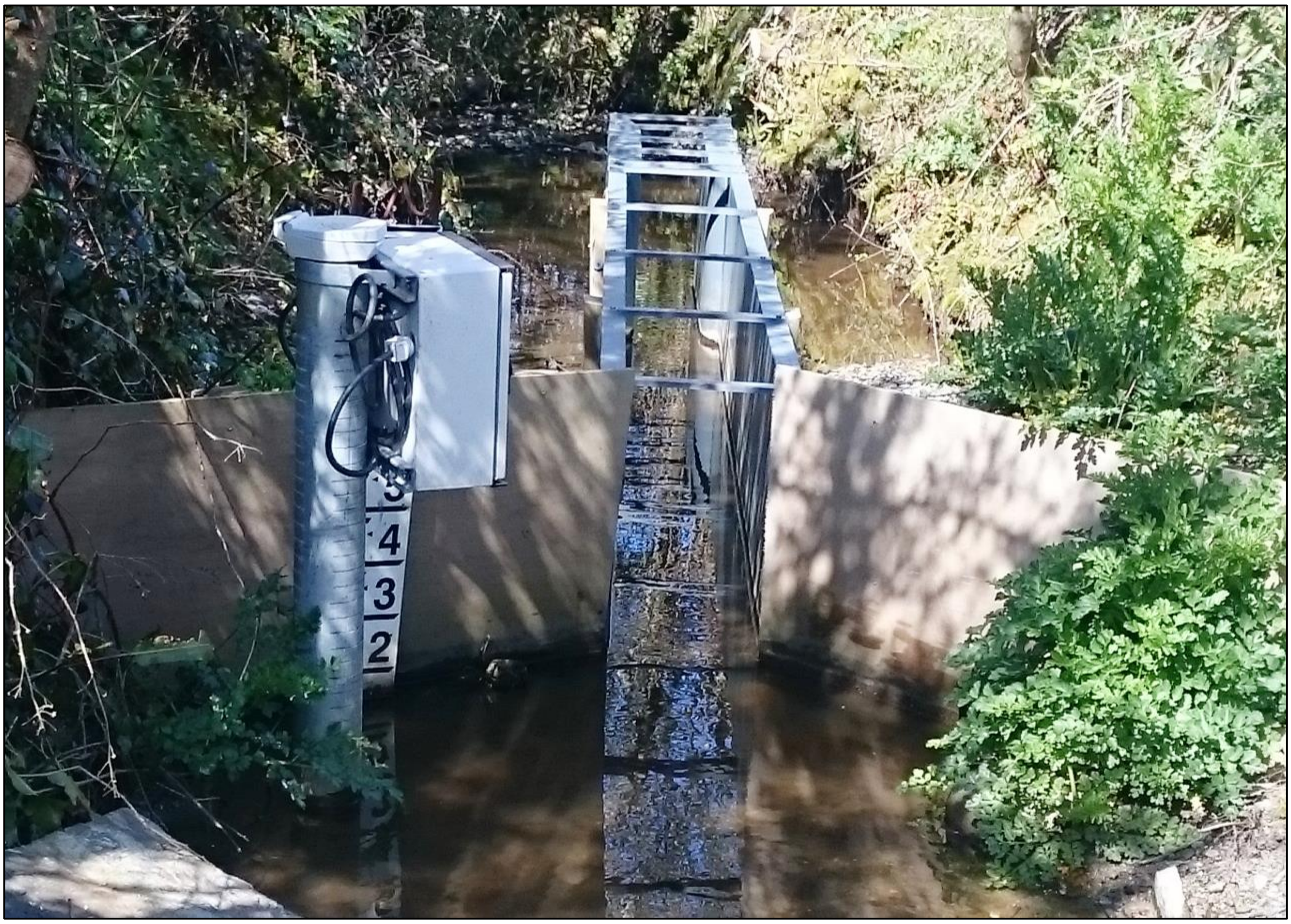
Regarding saturation of peat, type of substrate, presence of silt/sand in peat, vegetation, ease of piezometer installation, any issues with installation.

Core/Piezometer ID	NGR Easting	NGR Northing	Elevation (mAOD)	Photo ID (s)
CG_PZ_POB	234728	391936	22.87	-
Core Depth (m)	**Peat Depth (m)**	**Water table Depth (m)**	**Acrotelm Depth (m)**	**Catotelm Depth (m)**
-	1.75	Ground surface	No distinct acrotelm/catotelm layers	-
Von Post H Scores		**Von Post B Scores**		**Piezometer Installation Depth (m)**
Acrotelm	***Catotelm***	***Acrotelm***	***Catotelm***	
-	**-**	**-**	**-**	**-**

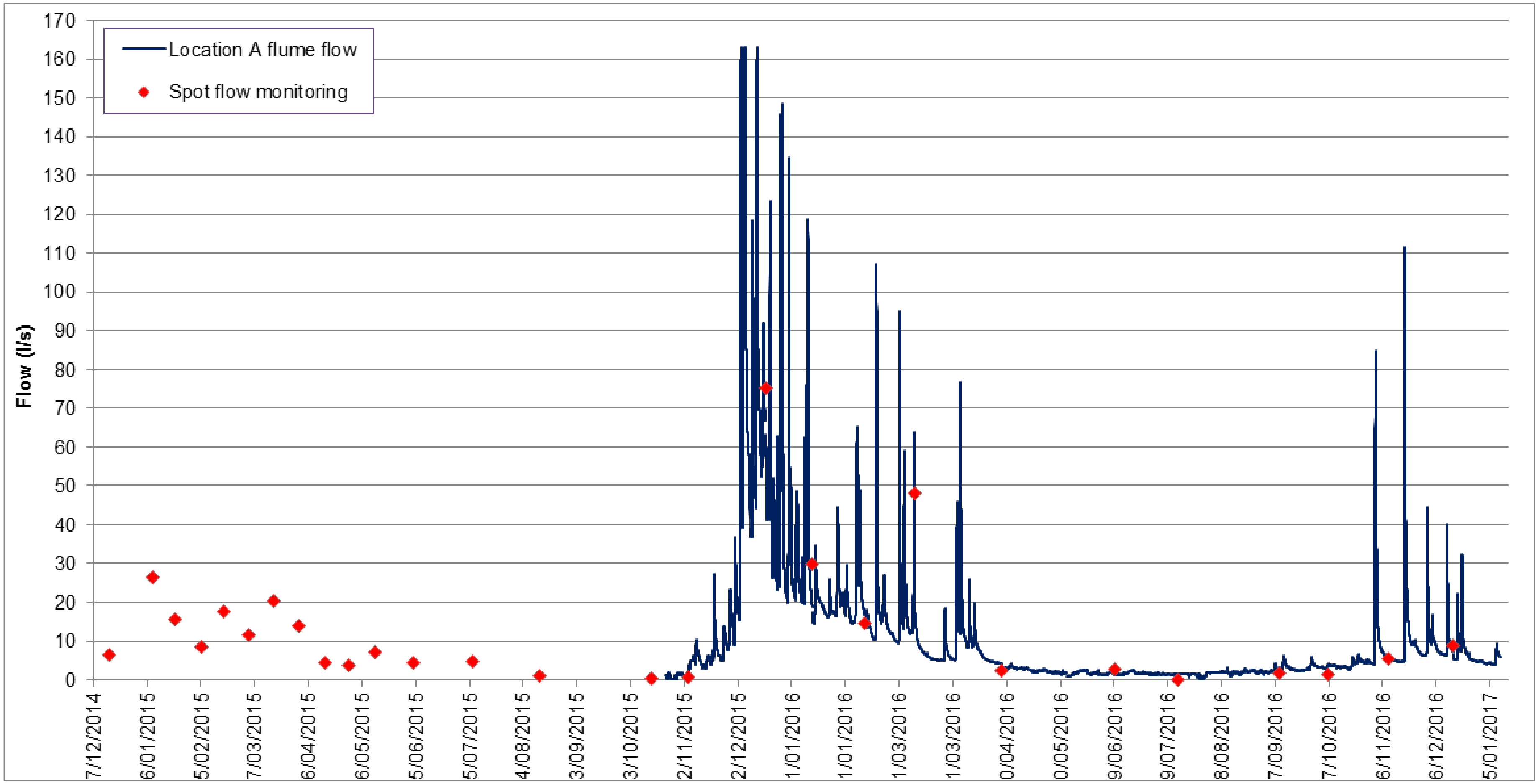
General Comments:

Regarding saturation of peat, type of substrate, presence of silt/sand in peat, vegetation, ease of piezometer installation, any issues with installation.

Annex E Nant Caerdegog Isaf flow

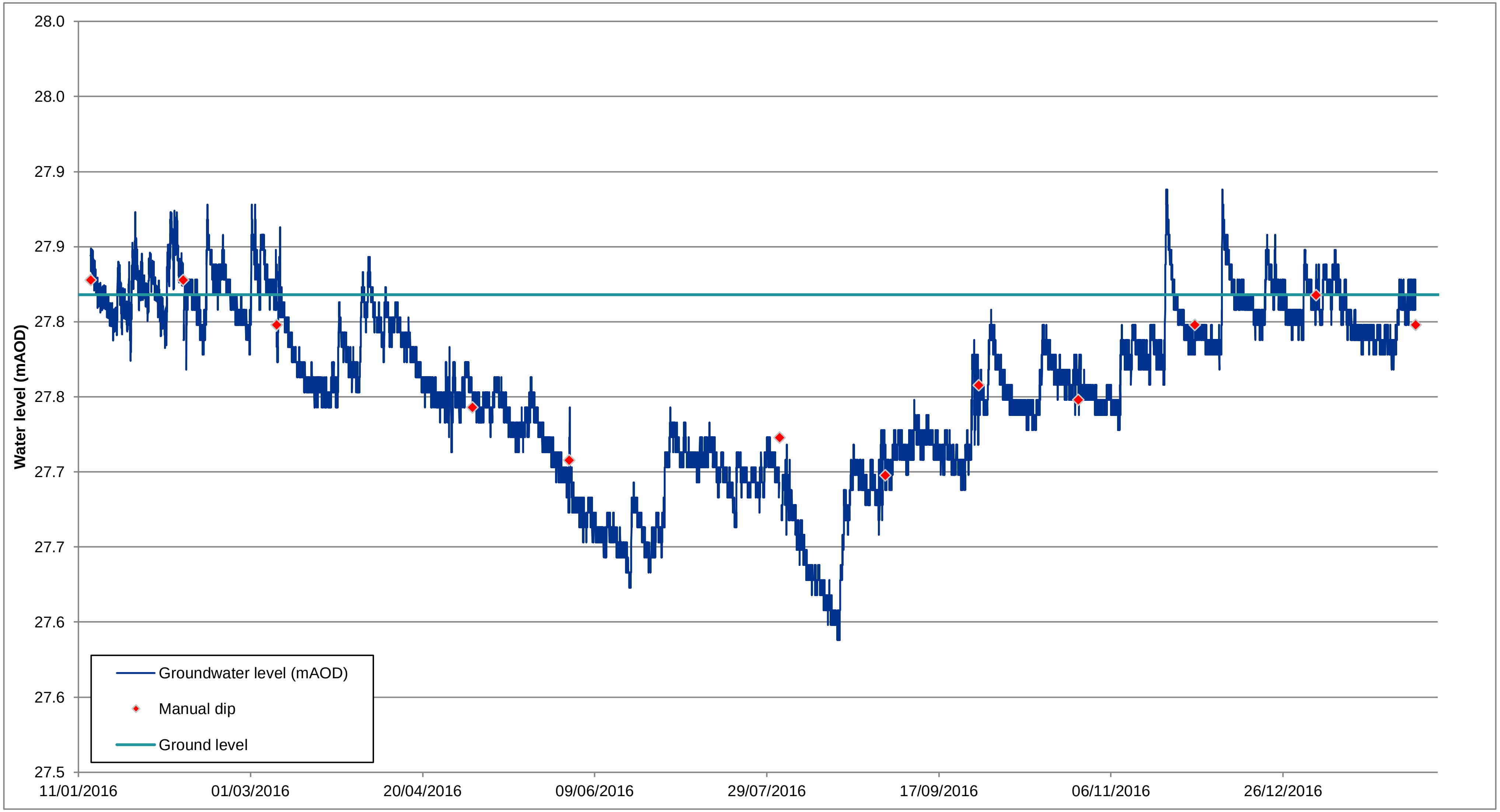

4
3
2

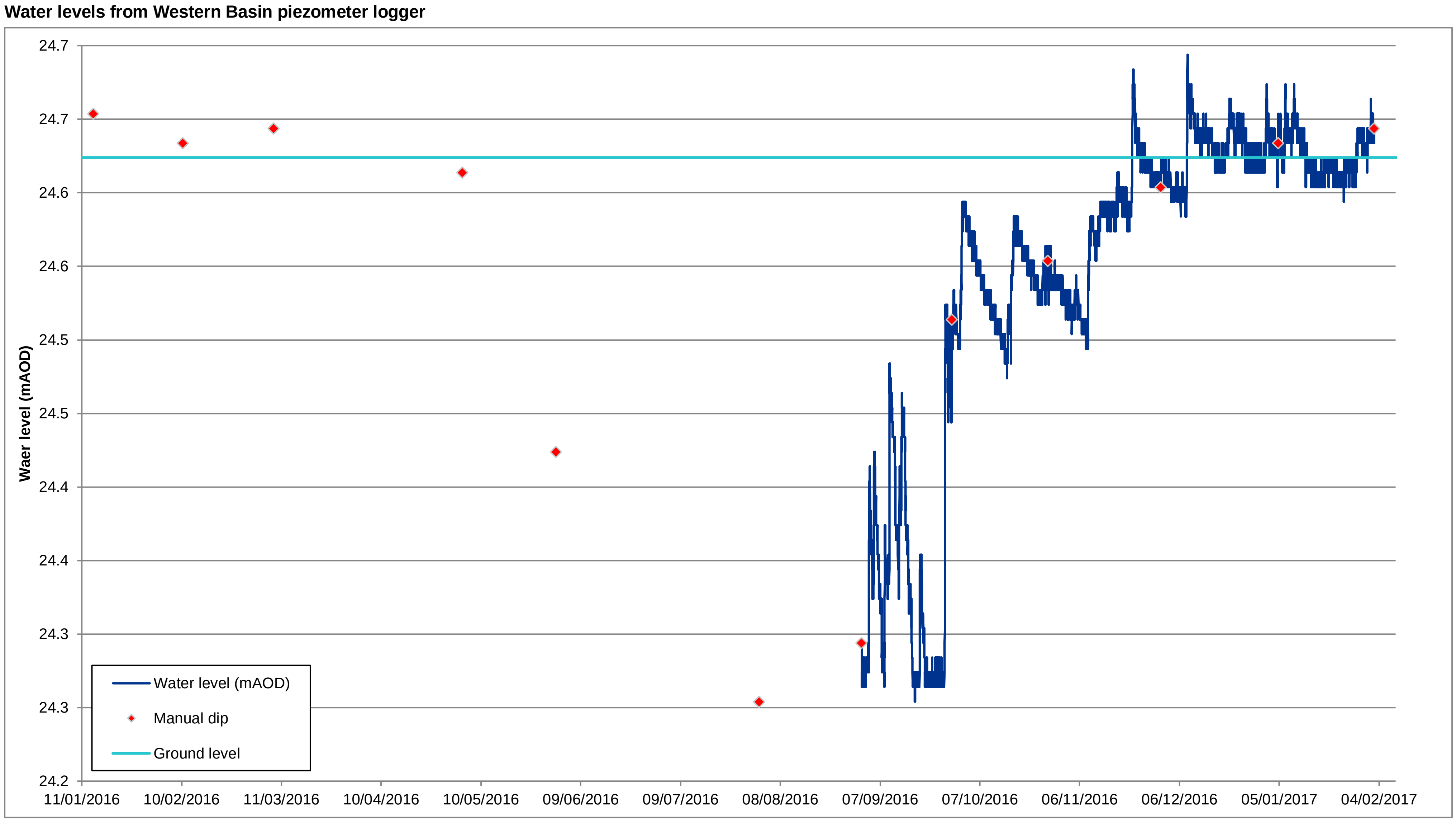
Flow in Nant Caerdegog Isaf at Location A



Annex F Piezometer logger plots

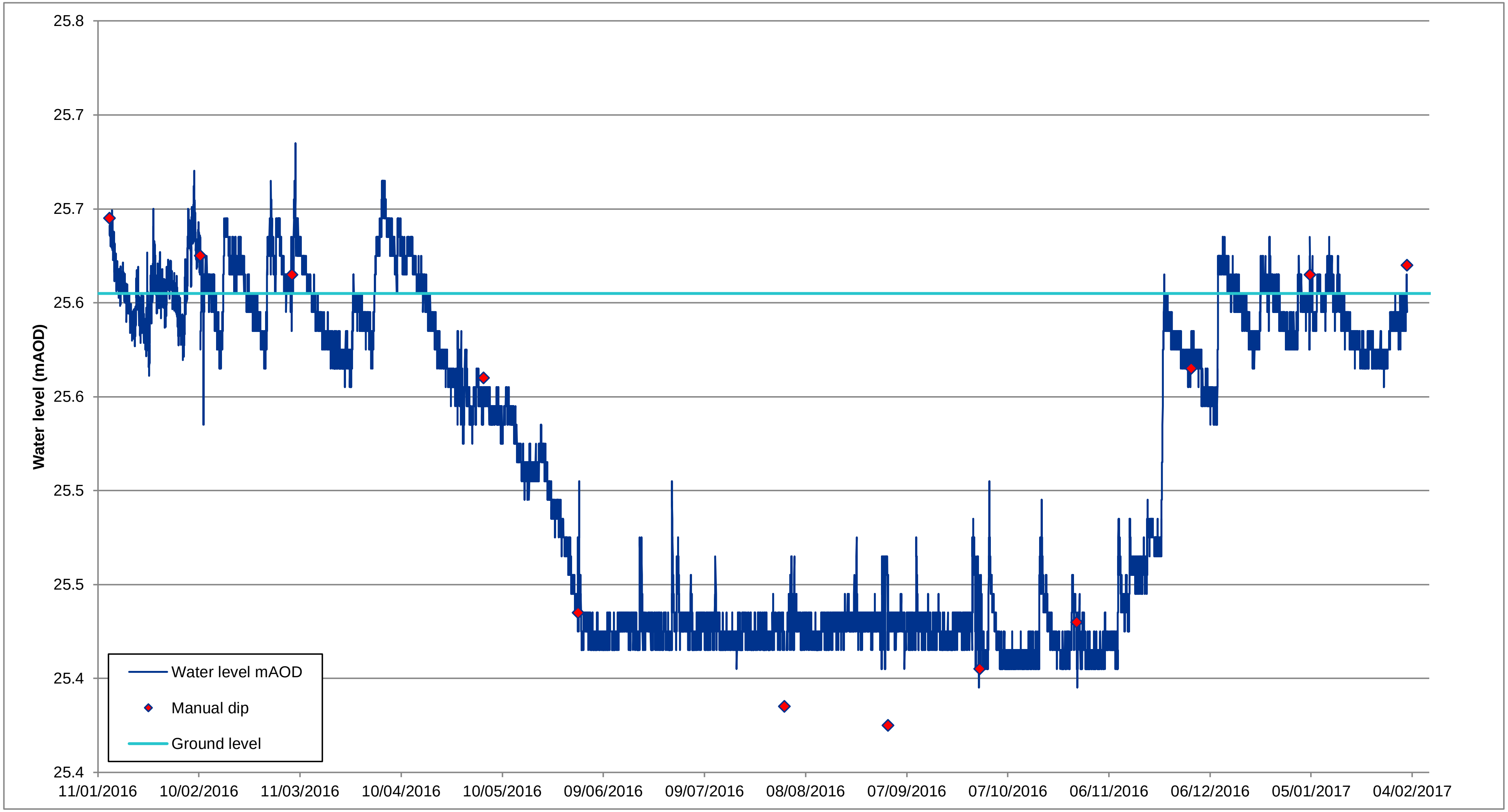
Water levels from Southern Basin piezometer logger



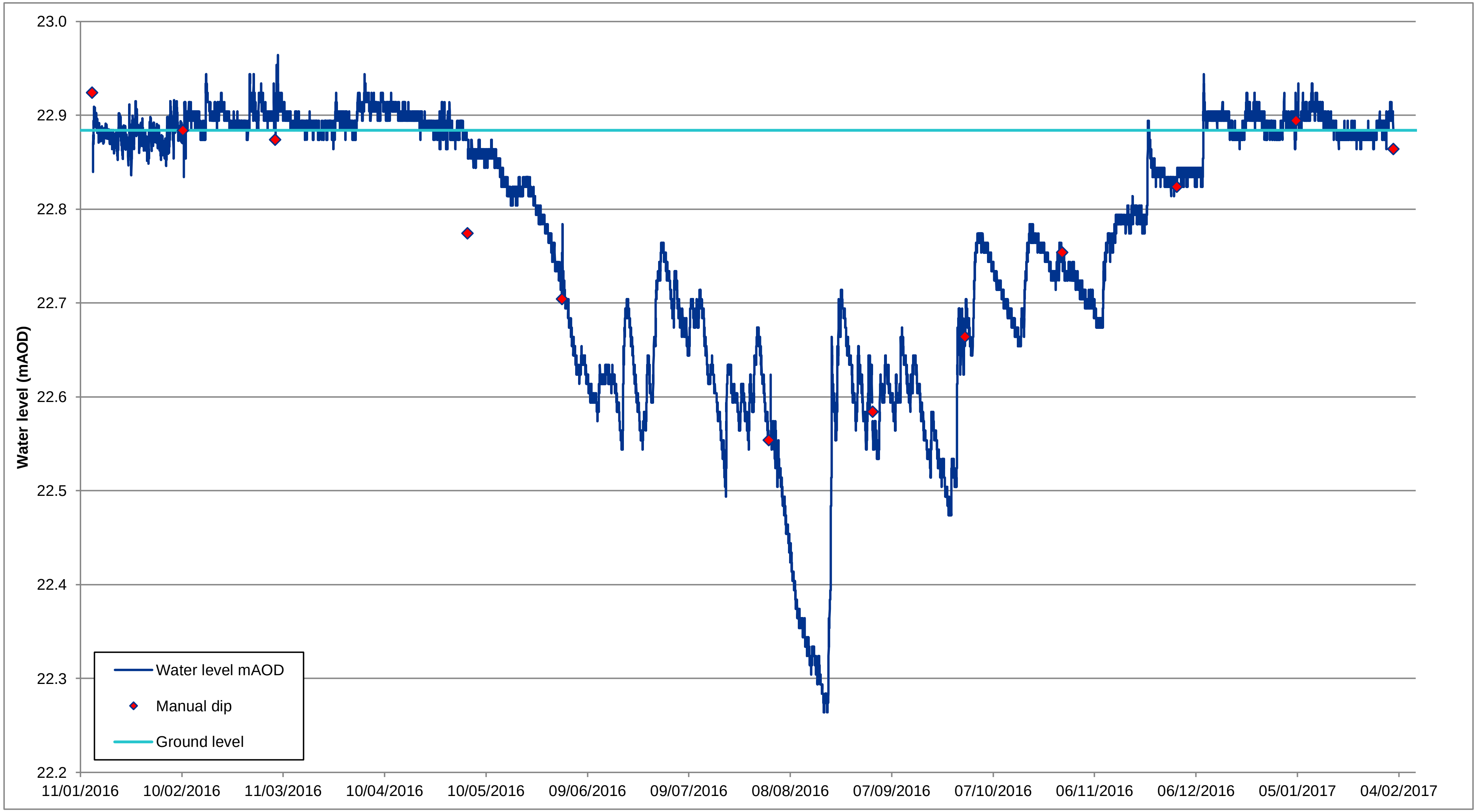


Water levels from Western Basin piezometer logger
Waer level (mAOD)
24.7
24.7
24.6
24.6
24.5
24.5
24.4
24.4
24.3
24.3
24.2
11/01/2016
10/02/2016
11/03/2016
10/04/2016
10/05/2016
09/06/2016
09/07/2016
08/08/2016
07/09/2016
07/10/2016
06/11/2016
06/12/2016
05/01/2017
04/02/2017
Water level (mAOD)
Manual dip
Ground level

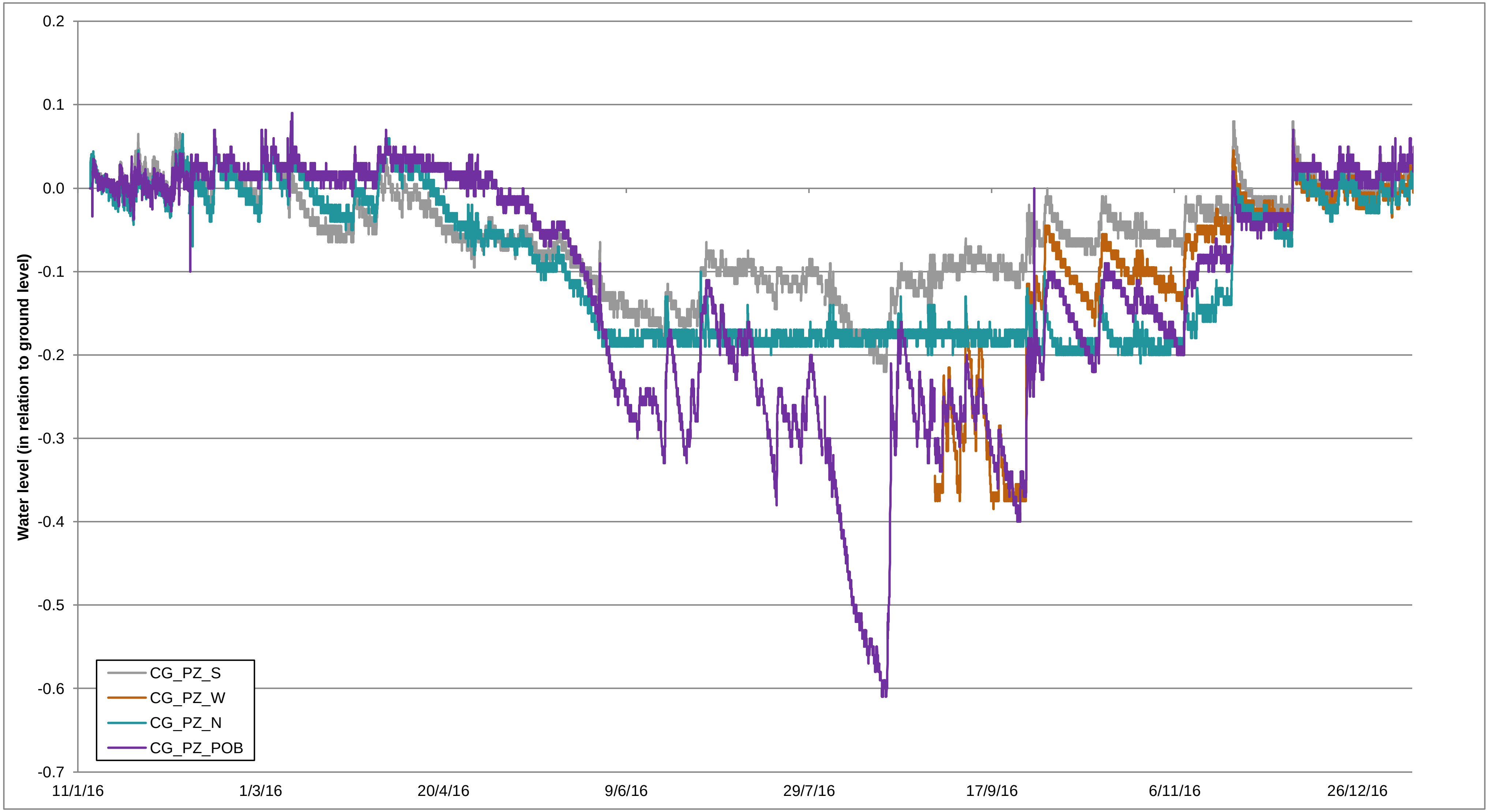
Water levels from Northern Basin piezometer logger



Water levels from POB piezometer logger



Water levels in all four piezometer loggers (in relation to ground level)



Annex G. Water balance

G1 Scope

The water balance has been prepared to provide an indication of likely water movements at the catchment scale rather than looking at individual parts of the SSSI associated with particular plant assemblages. Its purpose is to try to identify the most significant water inputs for the maintenance of the SSSI as a whole and has been used with other lines of evidence in preparing a conceptual site model. One of the main purposes of the water balance is to determine if there is substantial groundwater inflow to the SSSI that is not accounted for. Due to the nature of the water balance and the available data there are a number of inherent uncertainties and these need to be taken into account when interpreting the assessment. It is also recognised that there may be discrete groundwater inputs to seeps and flushes that are not included in the water balance, but which are important for the maintenance of some plant assemblages.

The key components of the water balance, and associated assumptions and uncertainties, are detailed below. It is not possible to put an absolute value on the accuracy of the water balance, but the results are likely to be the correct order of magnitude. Given the limitations to the accuracy of the water balance and uncertainty in many of the parameters, the water balance only provides an indication of likely bulk water movements to and from the SSSI. It is used in conjunction with other lines of evidence in developing the conceptual model for the Cae Gwyn SSSI.

An approximation of the catchment for each basin is contained in table D8.6.G1. The water balances are presented graphically below, and in a tabular format on a monthly basis in table D8.6.G2 to table D8.6.G5. Key observations that can be made with regards to the water balance for each basin are outlined below.

Table D8.6.G1 Cae Gwyn water balance – input information

	Southern Basin	Northern Basin	Primary Outflow Basin	Western Basin
Approximate basin area	10,031m^2	2,358m^2	21,833m^2	1,677m^2
Approximate basin catchment area	105,350m^2	16,790m^2	168,130m^2	8,020m^2

G2 Meteorological conditions

Rainfall and other meteorological data have been obtained for the Wylfa Newydd Development Area from an onsite meteorological station set up by Horizon. The station has provided data from February 2015 to November 2016, and records:

- rainfall;
- irradiance;
- wind speed and direction;
- temperature; and
- humidity.

The daily rainfall dataset from the meteorological station was checked against the Meteorological Office rainfall data for Llyn Alaw rain gauge, which is approximately 6km south of the Wylfa Newydd Development Area. This dataset shows a high correlation to the onsite rain gauge, and as such the information is considered sufficiently accurate for the purpose of the water balance, with the Llyn Alaw dataset used to fill a small gap in the onsite rainfall data. The other meteorological data was used to calculate potential evapotranspiration (ETo) for the water balance; this was undertaken using the Food and Agricultural Organization (FAO) of the United Nations Evapotranspiration calculator tool [RDG1]. The FAO guidance note [RDG1] does not give an estimate of the accuracy of the assessment method, but given the number of meteorological elements it relies on, the assumptions of the method and the variations even within a small area such as Cae Gwyn SSSI, the accuracy is not going to be high.

Rainfall is notoriously difficult to measure accurately with the siting of a gauge and micro climatic changes caused by topography, trees and any structures being critical. Wind is a key issue in accurate measurement. It is not possible to set an accuracy on the gauge used for the Cae Gwyn SSSI water balance, but values cited in the literature [RDG2] range from 2% to 20%. Uniform rainfall across the basin areas is assumed at the rate observed by the rain gauge located 1.5km north of Cae Gwyn SSSI. For the runoff from catchments a simple model of soil moisture deficit (area multiplied by rainfall minus potential ETo) was developed and applied to each catchment (minus the basin area) of each of the basins.

A review of the data recorded showed that there were large gaps in the wind speed and solar radiation records. Where gaps existed in the meteorological dataset, reasonable estimates appropriate to seasonal observed conditions were applied. Actual evapotranspiration from a 'normal' grassed surface was estimated using the soil moisture deficit model described above, assuming a root constant of 75mm which is appropriate for grass. For soil moisture deficits up to the root constant the actual evapotranspiration is equal to the potential evapotranspiration [RDG3].

G3 Southern Basin

The inflows and outflows for the Southern Basin are defined below, with an estimated water balance for the basin contained in table D8.6.G2.

Inflows

Direct rainfall inputs	Uniform rainfall across the Southern Basin assumed at the rate observed by the rain gauge, with no losses to groundwater. The Southern Basin area has been estimated from LiDAR and aerial imaging.
Runoff from the catchment	The majority of the catchment does not have any formal channels, so it is assumed that the majority of the catchment inflows to the basin via overland flow and soil/subsoil throughflow. A simple model of soil moisture deficit (area multiplied by rainfall minus potential ETo) was developed and applied to the entire catchment (minus the basin area). For the base model it is assumed that 90% of the incident rainfall becomes runoff into the basin and the remaining 10% infiltrates to groundwater. There is no technical basis for this, but it does provide a starting point for the assessment and is not unreasonable based on the presence of till around (as opposed to within) the SSSI. The catchment area has been estimated from LiDAR.
Road Drain inflows	Inflows to the basin from the Road Drain running into the south-east of the basin have been incorporated. Flows were not measured along this drain and its contributing catchment area is unknown. However, based on visual estimations the flow within the Road Drain was approximately half of the flow observed within the Southern Drain. Due to thick vegetation cover these drains could not be observed during the summer months, therefore the hydrological behaviour during dry weather is not known. The water balance has assumed steady flow from the Road Drain throughout the winter at a rate proportional to the flows estimated within the Southern Drain. There is a very high degree of uncertainty associated with this data.

Outflows

Potential evapotranspiration	Potential ETo was estimated using the ETo calculator, as detailed above. An estimate of evaporative losses from the Southern Basin was then derived. As the Southern Basin was noted to be wet throughout the summer, with water either at the surface or immediately below the surface of the sphagnum, potential ETo has been used for the basin.
Southern Drain outflows	Outflows from the basin were observed along the Southern Drain. It was not possible to monitor flows at this location. Based on a rough visual estimation the flow within this drain was between 50% and 10% of the flows along Nant Caerdegog Isaf at Location A. The catchment of Nant Caerdegog Isaf is estimated to be 0.64km^2 at Location A, compared to the Southern Basin Catchment of approximately 0.105km^2. The monitored flows at Location A have been scaled for the Southern Drain based upon the catchment sizes, however given the unique behaviour of the Southern Basin, this is unlikely to portray the true behaviour of the watercourse and is used here as a preliminary assessment. This is the element that has the greatest uncertainty within the water balance.

The water balance for the Southern Basin, based upon meteorological conditions and incorporation of estimated flow, has been compared to the change in water held within the Southern Basin, based on the assumption that a change in water level recorded in the piezometer indicates a volumetric change in water stored in the basin based upon the basin area. The water content of the sphagnum in the Southern Basin has been estimated at 60% by volume, given that the upper part of the basin comprises saturated plant matter, and as such any change in water level below the surface of the basin is assumed to be 0.6 of the calculated change in basin volume [RDG4]. This is only likely to apply to the upper part of the peat due to compression towards its base and so is a potential error in the calculation method.

Any potential groundwater inflow to the Southern Basin and/or loss of water from the Southern Basin to deeper groundwater is not included within the water balance. The purpose of the water balance is to try to establish whether groundwater flows are substantial; if such flows exist, these may be apparent as a discrepancy between inflows and outflows, although it should be noted that the uncertainty associated with the accuracy of the inflows and outflows is unlikely to result in any potential small scale groundwater contribution being identified.

Table D8.6.G2 Southern Basin monthly estimated water balance (shading shows imbalances with green showing inflows greater than outflows and brown *vice versa,* dark shading shows greater imbalances than light)

Month	Inflows (m^3)				Outflows (m^3)			Inflow/outflow difference (m^3)		Change in stored volume (piezometers)	
	Direct rainfall	Catchment runoff	Road Drain	Total inflows	Evapo-transpiration	Southern Drain	Total outflows	Meteorological water balance	Total water balance (inc. drains)	Water level (m)	Volume estimate (m^3)
Jan-16*	463	2,273	2,445	5,181	195	4,891	5,086	2,541	96	-0.016	-127
Feb-16	920	5,467	3,788	10,174	368	7,575	7,944	6,018	2,231	-0.031	-101
Mar-16	1,059	5,310	2,413	8,783	442	4,827	5,269	5,927	3,514	-0.028	-18
Apr-16	999	5,456	2,019	8,475	610	4,038	4,648	5,845	3,826	-0.022	409
May-16	560	0	548	1,107	817	1,095	1,912	-257	-805	-0.050	-182
Jun-16	923	0	363	1,286	804	727	1,531	118	-245	0.018	65
Jul-16	927	0	354	1,281	847	709	1,555	80	-274	-0.009	-32
Aug-16	835	0	338	1,172	823	675	1,498	12	-326	0.003	11
Sep-16	1,041	1,098	476	2,615	589	951	1,540	1,551	1,075	0.038	137
Oct-16	672	1,990	728	3,390	502	1,455	1,957	2,161	1,433	0.006	20
Nov-16*	413	1,158	410	1,981	181	820	1,000	1,391	981	0.027	99
Total				45,445 #			33,940#		11,506 #		281

*The data for these months are incomplete, approximately half a month for each.

note that a rounding error is present in the data

Taking into account the estimated Road Drain inflow and outflow along the Southern Drain, the water balance indicates an imbalance with inflows 134% greater than outflows over the whole monitoring period. The water balance shows a strong seasonal effect with outflows exceeding inflows in the May to August period indicating that the basin is draining during that time. The imbalance suggests that there is an unaccounted for outflow from the Southern Basin in the autumn and winter period, an error in the water balance, or a combination of both.

The only unaccounted for outflow is infiltration to groundwater which is a possibility across parts of the Southern Basin where rock is at the surface or mantled by a thin veneer of soil. It is therefore likely that at least some of the imbalance is due to groundwater recharge.

During the summer months of May to August 2016 there are data gaps regarding the inflows and outflows from the Southern Basin, as the Southern Drain and the Road Drain were not observed during these months due to access constraints. Therefore it is uncertain whether there was any flow within these watercourses during the summer so the water balance just includes estimated flows based on them being proportional to those at Location A (although in reality they could be zero).

Overall it is unlikely that groundwater inflows are a substantial proportion of the Southern Basin water balance, but there could be significant outflows to groundwater during winter and autumn and groundwater could be locally important to particular vegetation assemblages. If the runoff factor for the catchment area is reduced from 0.9 to 0.45 the water balance is in balance indicating substantial groundwater recharge under this scenario. With regard to potential errors, the largest are associated with inflows along the Road Drain and outflows along the Southern Drain, both of which are estimates based on limited observations, particularly during the summer.

G4 Northern Basin

The inflows and outflows for the Northern Basin are defined below, with an estimated water balance for the basin contained in table D8.6.G3.

Inflows

Direct rainfall inputs	Uniform rainfall across the Northern Basin assumed at the rate observed by the rain gauge. The Northern Basin area has been estimated from LiDAR and aerial imaging.
Runoff from the catchment	The catchment does not have any formal channels, so it is assumed that the catchment inflows to the basin via overland flow and soil/subsoil throughflow. A simple model of soil moisture deficit (area multiplied by rainfall minus potential ETo) was developed and applied to the entire catchment (minus the basin area). For the base model it is assumed that 90% of the incident rainfall becomes runoff into the basin and the remaining 10% infiltrates to groundwater. There is no technical basis for this, but it does provide a starting point for the assessment. The catchment area has been estimated from LiDAR.

Outflows

Potential Evapotranspiration	Potential ETo was estimated using the ETo calculator, as detailed above. An estimate of evaporative losses from the Northern Basin was then derived based on observations. It is assumed that the majority of the basin (90%) developed a soil moisture deficit (actual ETo) and 10% (the northern pond) was permanently saturated (potential ETo).

No formalised inflows or outflows were observed associated with the Northern Basin. Based on the survey of ground elevation and the recorded water level in the piezometer, during wet periods the water level exceeds the height of the land between the Northern Basin and the POB. Therefore although there is no direct overland flow pathway, it is highly likely that water does flow from the basin during wet periods.

Any potential groundwater inflow that enters the Northern Basin and/or losses of water from the catchment or wetland to deeper groundwater are not included within the water balance, with the exception of 10% losses from the catchment area which are assumed to infiltrate to groundwater. If other flows exist these may be apparent as a discrepancy between inflows and outflows.

As the Northern Basin has a small catchment, the meteorological changes are relatively small compared with the other basins. Over the monitoring period, but especially during the winter months, the meteorological water balance shows that there are larger inflows to the basin than outflows, and generally these do not correspond to an overall increase in water level within the basin. This indicates that there are losses from the basin, likely due to a combination of an informal overland flow route to the POB and losses to groundwater. In the winter it is likely that there are significant losses via overland flow (overflowing once the level reaches 25.7mAOD) given the relative surveyed land levels and observed boggy areas downstream of the basin.

Outflows exceed inflows in May suggesting that the Northern Basin is drying slightly, whilst in June, July and August the basin is close to be in balance.

The water balance has been compared to the change in water held within the Northern Basin, based on the assumption that a change in water level recorded in the piezometer indicates a volumetric change in the basin based upon the basin area. The effective porosity of the mineral soils has been assumed to be 5%, and as such any change in water level below the surface of the basin is assumed to be 5% of the calculated change in basin volume [RDG4]. The changes in storage are not significant enough to account for the imbalance in the water balance. Overall the water balance does not suggest that groundwater inflows are a substantial proportion of the water balance.

Table D8.6.G3 Northern Basin monthly estimated water balance (shading shows imbalances with green showing inflows greater than outflows and brown *vice versa,* dark shading shows a greater imbalance than light)

Month	Inflows (m^3)			Outflow (m^3)		Inflow/outflow difference (m^3)	Basin change (piezometers)	
	Direct rainfall	Catchment runoff	Total inflows	Evapo-transpiration	Total outflows		Water level (m)	Volume estimate (m^3)
Jan-16*	109	344	453	46	46	407	-0.031	-73
Feb-16	216	828	1,044	87	87	957	-0.030	-44
Mar-16	249	804	1,053	104	104	949	0.008	32
Apr-16	235	826	1,061	143	143	918	-0.043	27
May-16	132	0	132	192	192	-60	-0.096	-6
Jun-16	217	0	217	189	189	28	-0.011	-2
Jul-16	218	0	218	199	199	19	-0.009	-2
Aug-16	196	0	196	193	193	3	-0.013	-3
Sep-16	245	166	411	138	138	273	0.000	0
Oct-16	158	301	459	118	118	341	0.001	0
Nov-16*	97	175	273	42	42	230	0.043	10
Total			5,517#		1,451#	4,065#		-61
*The data for these months are incomplete, approximately half a month for each # note that a rounding error is present in the data								

G5 Primary Outflow Basin

The inflows and outflows for the POB are defined below, with an estimated water balance for the basin contained in table D8.6.G4.

Inflows

Direct rainfall inputs — Uniform rainfall across the POB assumed at the rate observed by the rain gauge located 1.5km north of Cae Gwyn SSSI. The POB area has been estimated from LiDAR and site observations.

Runoff from the catchment — Most of the POB catchment is without formal channels, so it is assumed that the majority of the catchment inflows to the basin via overland flow and soil/subsoil throughflow. A simple model of soil moisture deficit (area multiplied by rainfall minus potential ETo) was developed and applied to the entire catchment (minus the basin area). For the base model it is assumed that 90% of the incident rainfall becomes runoff into the basin and the remaining 10% infiltrates to groundwater. The catchment area has been estimated from LiDAR.

Inflows from Southern Drain — Inflows to the POB from the Southern Basin, via the Southern Drain, have been incorporated. As noted in Section 2.6.3 it was not possible to monitor flows at this location. The monitored flows at Location A have been scaled for the Southern Drain based upon the catchment sizes, however given the unique behaviour of the Southern Basin this is unlikely to portray the true behaviour of the watercourse.

Outflows

Potential Evapotranspiration	Potential ETo was estimated using the ETo calculator, as detailed above. An estimate of evaporative losses from the Southern Basin was then derived assuming that the majority of the basin was able to develop a soil moisture deficit (actual ETo) based on observations, and that 10% of the basin was permanently saturated (potential ETo).
Nant Caerdegog Isaf	It was not possible to monitor flows along Nant Caerdegog Isaf at Cae Gwyn SSSI. However, flows were monitored along Nant Caerdegog Isaf approximately 800m downstream of Cae Gwyn SSSI. Nant Caerdegog Isaf is estimated to have a catchment of 0.64km^2 at Location A. The flows leaving the site have been scaled to fit the outflow from Cae Gwyn SSSI, which includes the Southern Basin and POB catchments, based upon a comparison of catchments.

The water balance for the POB has been compared to the change in water held within the POB, based on the assumption that a change in water level recorded at the piezometer indicates a volumetric change in the water stored in the basin based upon the basin area. The water content of the silty peat in the POB has been estimated at 20% by volume, which is less than the Southern Basin based on observed peat densities. The change in the volume of water stored in the basin due to changes in water level is therefore calculated by multiplying the basin area by the change in water level multiplied by 0.2 [RDG4].

Groundwater inflows that enter the wetland basin and/or losses of water from the catchment or wetland to deeper groundwater are not included within the water balance. If such flows exist, these may be apparent as a discrepancy between inflows and outflows.

Table D8.6.G4 POB monthly estimated water balance (shading shows imbalances with green showing inflows greater than outflows and brown *vice versa,* dark shading shows a greater imbalance than light)

Month	Inflows (m^3)				Outflows (m^3)			Inflow/outflow difference (m^3)		Basin change (piezometers)	
	Direct rainfall	Catchment runoff	Southern Drain	Total inflows	Evapo-transpiration	To Nant Caerdegog Isaf	Total outflows	Meteorological water balance	Total water balance (inc. drains)	Water level change (m)	Volume estimate (m^3)
Jan-16*	1,009	3,488	4,891	9,388	424	12,697	13,120	4,073	-3,732	0.010	293
Feb-16	2,002	8,390	7,575	17,967	800	19,665	20,466	9,591	-2,499	0.009	222
Mar-16	2,306	8,150	4,827	15,283	943	12,530	13,493	9,493	1,790	0.002	45
Apr-16	2,175	8,374	4,038	14,587	1,265	10,484	11,811	9,221	2,776	-0.007	-150
May-16	1,218	0	1,095	2,314	1,502	2,844	4,621	-559	-2,307	-0.147	-773
Jun-16	2,009	0	727	2,736	1,160	1,887	3,638	258	-902	0.004	15
Jul-16	2,017	0	709	2,726	1,820	1,840	3,682	175	-956	-0.137	-598
Aug-16	1,817	0	675	2,492	1,585	1,753	3,543	26	-1,051	0.012	54
Sep-16	2,266	1,685	951	4,903	1,279	2,469	3,751	2,670	1,152	0.045	197
Oct-16	1,463	3,055	1,455	5,973	1,058	3,777	4,869	3,426	1,104	0.069	303
Nov-16*	900	1,778	820	3,497	375	2,128	2,521	2,284	976	0.060	262
Total				81,866			85,515		-3,649		-129

*The data for these months are incomplete, approximately half a month for each

The water balance indicates that for the whole monitoring period inflows are 96% of ouflows which is the closest of all of the basins to being in balance and does not suggest that there are any substantial inflows or outflows that are unaccounted for. However, there are significant monthly differences, the most notable of which are those in January and February, when unusually for winter the outflows exceed the inflows, which could indicate groundwater inflow and overland flow from the Northern Basin. There is also a greater outflow than inflow in May, June, July and August although this is likely due to a different mechanism as in this period rainfall recharge was low and the POB was likely draining, although this is not consistent with the measured change in water levels. The difference between inflows and outflows could also be associated with inaccuracies in the water balance.

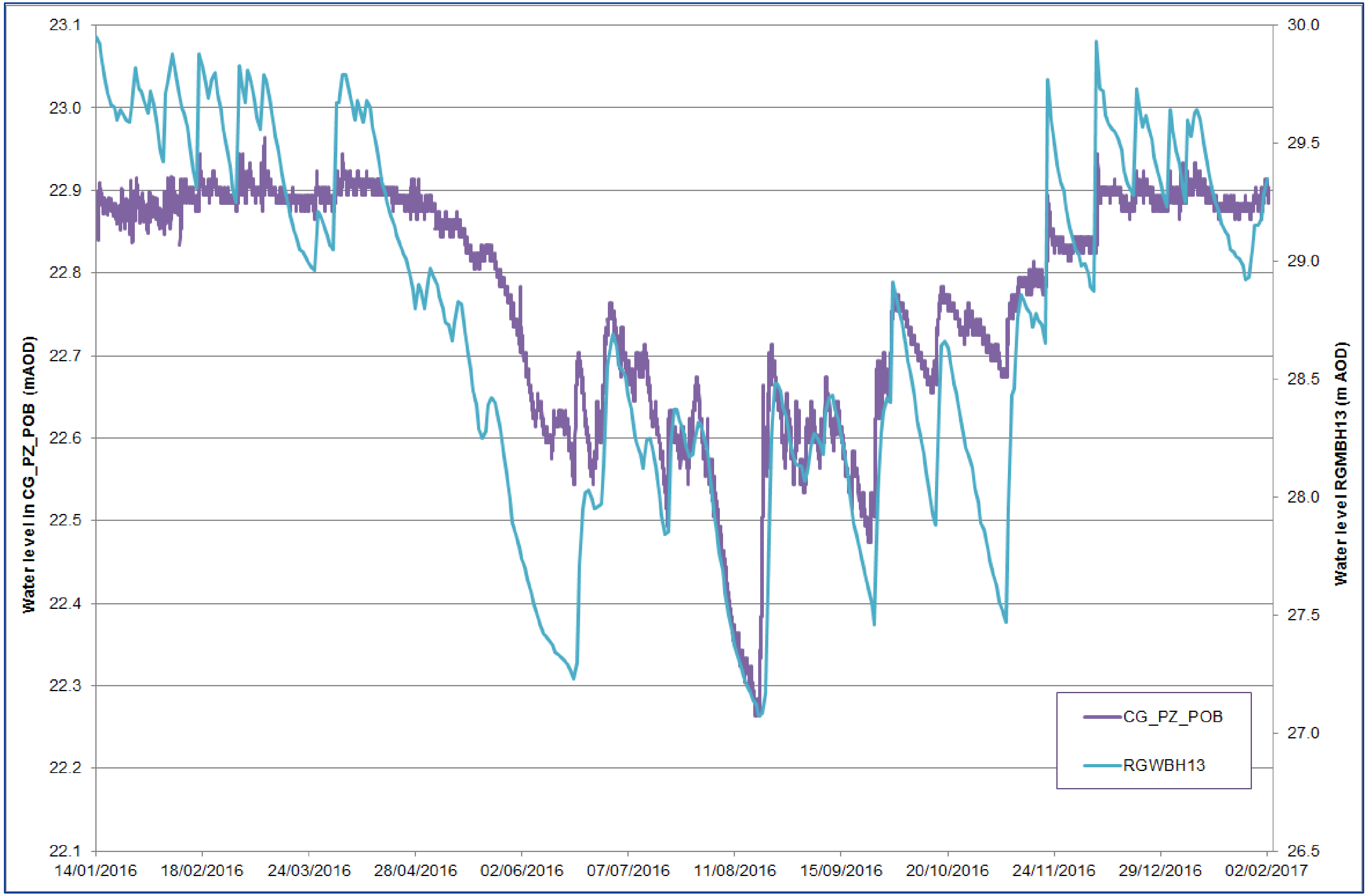
The assertion that there is significant groundwater inflow to the POB in winter is supported when groundwater levels in borehole RGWBH13 are compared to water levels in the piezometer within the POB. The scales have been adjusted so that the water level plots overlap and this clearly shows that in January and February 2016 groundwater levels fluctuated in RGWBH13 but there was little change in the water levels in the piezometer in the peat. This is because the water level in the peat was at ground level in the POB (Figure B7.06.2.3) with water flowing to the POB discharge point. In this situation groundwater levels are high, the peat is fully saturated, resulting in overflow to surface water.

In the summer months, from May through to August 2016, the water level is reducing in the peat and is below ground level as the peat is draining to the POB outfall point (as evidenced by the negative water balance). Water level fluctuations in the peat match reasonably well the groundwater level changes (in terms of fluctuation rather than absolute changes) suggesting that they are both responding to rainfall in a similar way.

Although RGWBH7 is much closer to the POB than RGWBH13, the water level data from the former have not been compared to water levels in the peat as water levels in RGWBH7 show little annual variation and appear to be controlled by surface water levels in the Nant Caerdegog Isaf which is close to it.

The water balance suggests that there is a small inflow to the POB that is not identified in the calculations, the source of which is likely to be associated with a combination of groundwater influx, flow from the Northern Basin and uncertainties in the calculation. Overall the water balance does not indicate substantial groundwater inflow or outflow, although groundwater could be important at a local scale in supporting particular vegetation assemblages.

Water levels in the POB compared to groundwater levels in RGWBH13 (note different vertical scales)



G6 Western Basin

The inflows and outflows for the Western Basin are defined below, with an estimated water balance for the basin contained in table B7.06.G5.

Inflows

Direct rainfall inputs	Uniform rainfall across the Western Basin is assumed to be at the rate observed by the rain gauge. The Western Basin area has been estimated from LiDAR and aerial imaging.
Runoff from the catchment	The catchment does not have any formal channels, so it is assumed that the catchment inflows to the basin via overland flow and soil/subsoil throughflow, as defined by a model. A simple model of soil moisture deficit (area multiplied by rainfall minus potential ETo) was developed and applied to the entire catchment (minus the basin area). For the base model it is assumed that 90% of the incident rainfall becomes runoff into the basin and the remaining 10% infiltrates to groundwater. The catchment area has been estimated from LiDAR.

Outflows

Potential Evapotranspiration	Potential ETo was estimated using the ETo calculator, as detailed above. An estimate of evaporative losses from the Western Basin was then derived based on observations. It is assumed that the entire basin was able to develop a soil moisture deficit (actual ETo) based upon observations.

Although the Western Drain rises at the boundary of the SSSI, it is not connected by a formal drainage channel to the Western Basin.

Table D8.6.G5 Western Basin monthly estimated water balance (shading shows imbalances with green showing inflows greater than outflows and brown *vice versa,* darker shading shows greater differences than light)

Month	**Inflows (m^3)**			**Outflow (m^3)**		**Inflow/outflow difference (m^3)**	**Basin change (piezometers)**	
	Direct rainfall	Catchment runoff	Total inflows	Evapo-transpiration	Total outflows		Water level (m)	Volume estimate (m^3)
Jan-16*	77	151	229	33	33	196	-0.020	-34
Feb-16	154	364	518	62	62	456	0.010	17
Mar-16	177	353	531	74	74	457	-0.013	-22
Apr-16	167	363	530	102	102	428	-0.017	-29
May-16	94	0	94	137	137	-43	-0.190	-32
Jun-16	154	0	154	134	134	20	-0.100	-17
Jul-16	155	0	155	142	142	13	-0.070	-12
Aug-16	140	0	140	138	138	2	0.040	7
Sep-16	174	73	247	98	98	149	0.226	38
Oct-16	112	132	245	84	84	161	0.033	6
Nov-16*	69	77	146	30	30	116	0.051	8
Total			2,989		1,034	1,955		-69

*The data for these months are incomplete, approximately half a month for each.

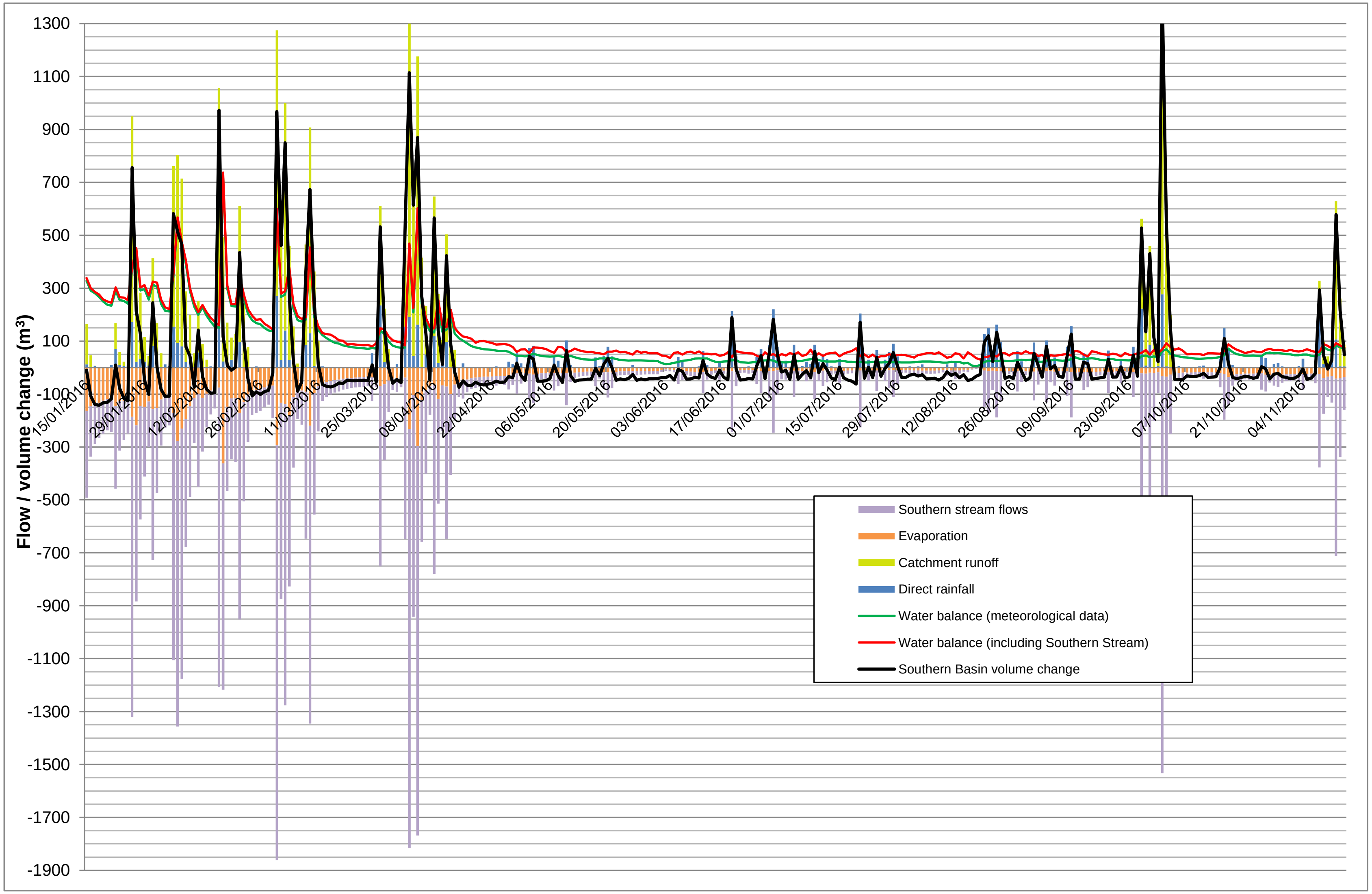
Any potential groundwater inflow that enters the Western Basin and/or losses of water from the catchment or wetland to deeper groundwater are not included within the water balance. If such flows exist, these may be apparent as a discrepancy between inflows and outflows.

The Western Basin is small, and therefore the water volumes are less significant to Cae Gwyn than for the other basins. For the monitoring period as a whole, and with the exception of May, the outflows exceed the inflows by 289%, suggesting that there is either an inflow of groundwater to the basin, or that there is overland flow from the basin to the Western Drain. The imbalance is likely due to a combination of these in addition to inaccuracies in the methodology. In May the water balance indicates very slightly more outflows than inflows, which corresponds to the reduction in water level during this month. In the summer months (May to August) the water balance is close to being neutral indicating that there are no significant unrecorded inflows or outflows during this period.

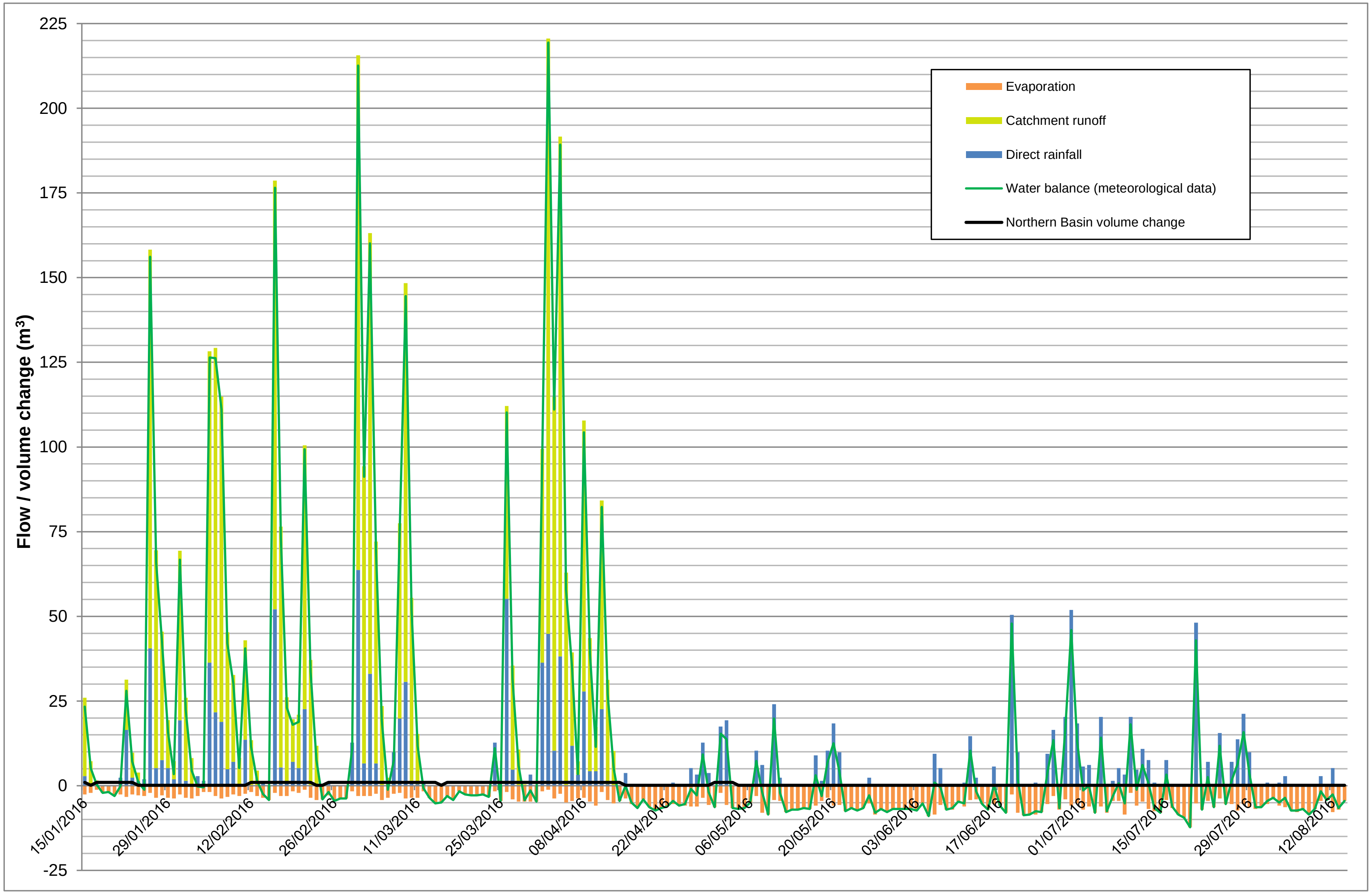
The water balance for the Western Basin has been compared to the change in the volume of water stored within the Western Basin, based on the assumption that a change in water level recorded in the piezometer indicates a volumetric change in the basin based upon the basin area. The effective porosity of the mineral soils has been assumed to be 5%, and as such any change in water level below the surface of the basin is assumed to be 5% of the calculated change in basin volume [RDG4]. The piezometer logger within the Western Basin was recording incorrectly through the first half of the water balance period, and as such the changes to water depth are based on manual dips, which sometimes fall a few days after the beginning of each month and so may not be a true reflection of the actual change. Overall, the changes in volume due to water level changes are insignificant in comparison to the volumes in the water balance and so water level changes (and therefore storage) are not important for the water balance.

ID	**Reference**
RDG1	Food and Agriculture Organisation of the United Nations, 2012, The ETo Calculator, evapotranspiration from a reference surface, Version 3.2.
RDG2	Gregory, K.J and D.E.Walling. 1973. Drainage basin form and process, a geomorphological approach. Edward Arnold, London.
RDG3	Shaw, E.M., 1994, Hydrology in Practice (third edition), Chapman & Hall, London.
RDG4	Price, J. 1996. Soil moisture, water tension, and water table relationships in a managed cutover bog. Journal of Hydrology. Elsevier. Vol. 292, Issues 1-4, December 1997, pp. 21-32.

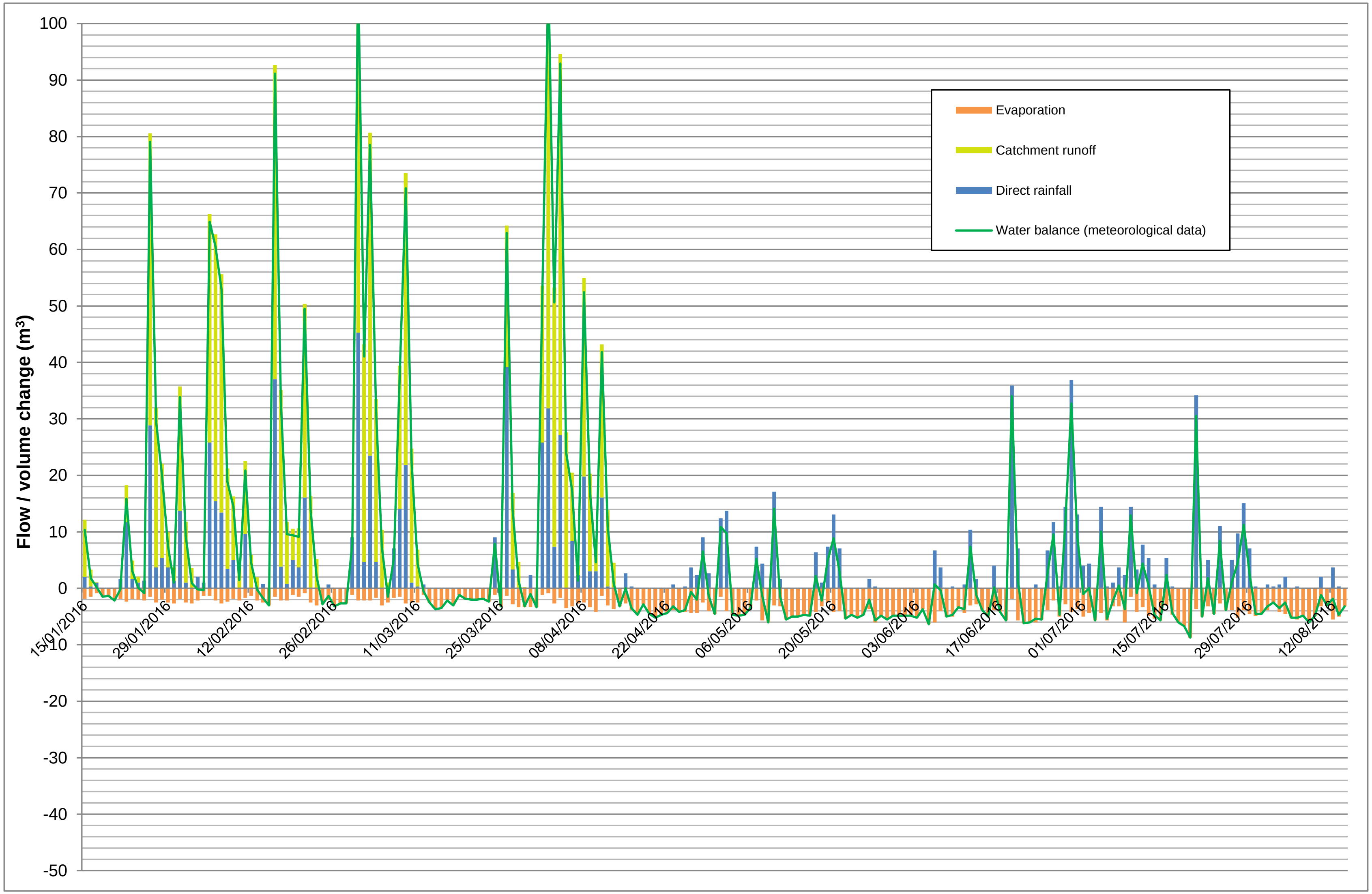
Southern Basin water balance



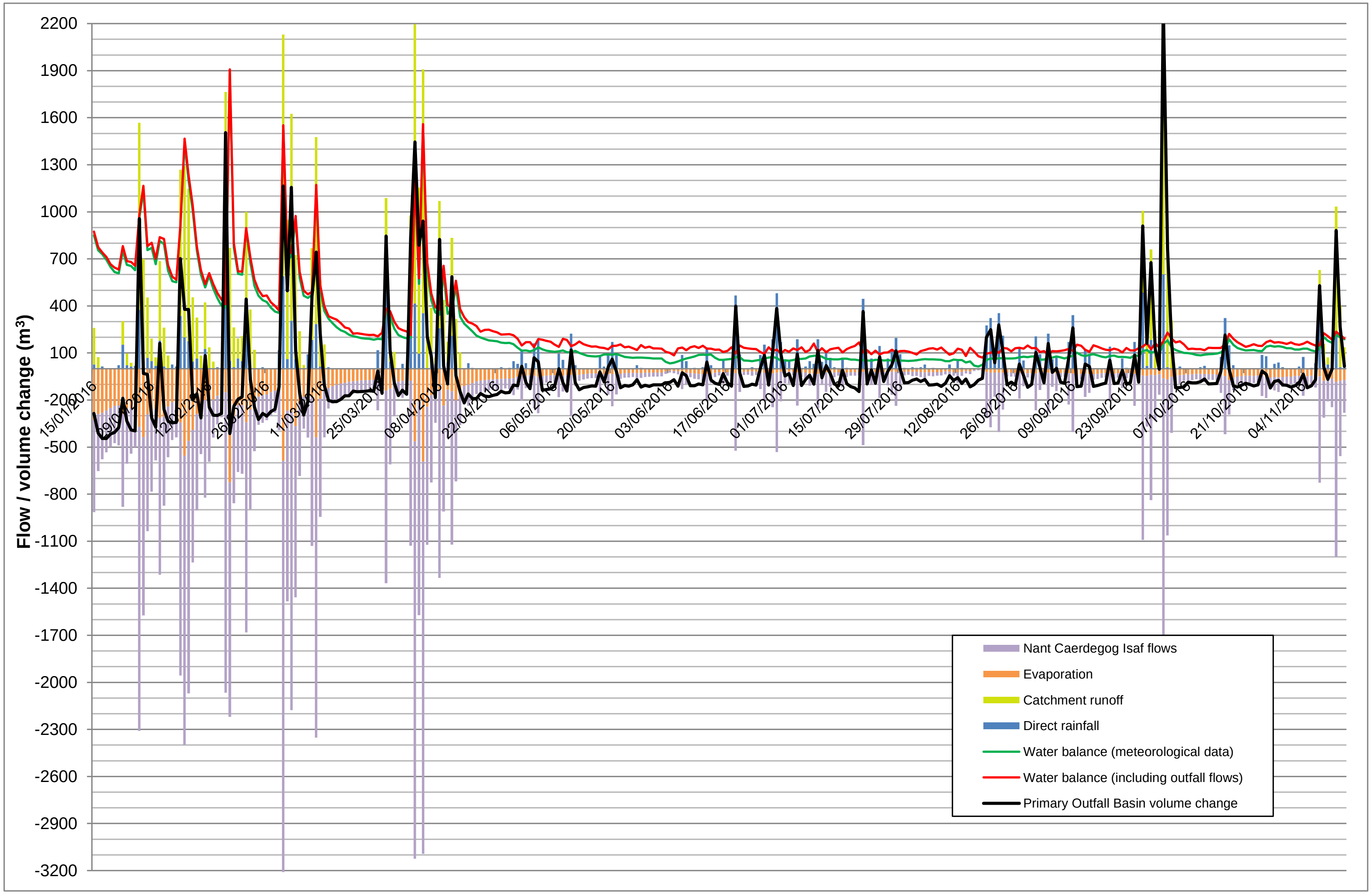
Northern Basin water balance



Western Basin water balance



POB water balance



Annex H. Water quality results

H.1 *In situ* water quality results

Sample ID	Date	pH	EC	DO	Redox	Temperature
		pH units	µS/cm	%	mV	°C
CG_S	03/11/2015	5.47	216	65.1	94	13
CG_S	16/12/2015	6.92	208	-	14	10.8
CG_Pob	16/12/2015	6.92	256	0	12	10.3
CG_Outfall	03/11/2015	7.25	570	57	52	10.7
CG_Outfall	16/12/2015	6.92	269	-	41	10.6
CG_Outfall	14/01/2016	5.91	289	-	107	4.9
CG_Outfall	10/02/2016	6.08	325	70.5	65	7.6
CG_Outfall	08/03/2016	6.14	269	92.2	37	8.5
CG_Outfall	26/04/2016	7.78	397	49	85	11.2
CG_Outfall	01/08/2016	6.61	539	31.4	46	15.2
CG_Outfall	27/10/2016	6.82	352	38.6	73	13.6
CG_Outfall	30/11/2016	6.25	346	60.4	59	9.6
CG_Outfall	04/01/2017	7.04	334	-	58	9.5
CG_Outfall	02/02/2017	7.25	326.9	84.2	57	11.1
CG_ODrain	03/11/2015	6.67	758	29.2	35	11
CG_ODrain	04/01/2017	6.94	227	-	56	9.1
CG_ODrain	02/02/2017	7.08	368.2	87.7	79	9.9
CG_NPond	03/11/2015	6.53	459	74.5	116	11.1
CG_NPond	16/12/2015	7.67	216	-	68	9.8
CG_NPond	10/02/2016	5.6	162	78.1	53	4.3
CG_NPond	08/03/2016	6.36	126	119	0	9.3
CG_NPond	01/08/2016	6.76	390	85.7	66	20.6
CG_NPond	27/10/2016	7.23	483	81.5	230	12.9
CG_NPond	30/11/2016	6.03	262	16.4	59	4.8
CG_NPond	04/01/2017	6.48	194	-	-44	7.6
CG_NPond	02/02/2017	7.06	175.9	57.5	20	10.2
CG_SDrain	10/02/2016	5.31	219	82.7	34	5.4
CG_SDrain	09/03/2016	5.8	186	89.7	92	7.8
CG_SDrain	27/10/2016	7.05	206	58	90	13.5
CG_SDrain	30/11/2016	6.55	223	80.1	54	7.4
CG_SDrain	05/01/2017	5.63	262	-	98	4.7
CG_SDrain	02/02/2017	7.7	289	100.6	67	10
CG_Road	10/02/2016	5.29	319	93.2	42	6.8
CG_Road	09/03/2016	5.67	337	93.7	61	7.2
CG_Road	27/10/2016	7.75	333	66.5	65	13.6
CG_Road	30/11/2016	6.58	322	97.1	56	10.5
CG_Road	05/01/2017	5.79	352	-	90	6
CG_Road	02/02/2017	7.64	396.3	101.5	73	9.

Sample ID	Date	pH	EC	DO	Redox	Temperature
		pH Units	µS/cm	%	mV	°C
CG_WDrain	08/03/2016	5.87	325	89.8	31	8.3
CG_WDrain	30/11/2016	5.94	355	24.4	38	7.3
CG_WDrain	04/01/2017	6.25	351	-	9	8.2
CG_WDrain	02/02/2017	6.77	324.7	101.4	44	10.2
CG_Well	10/02/2016	5.7	108	92.3	42	6
CG_Well	09/03/2016	5.69	92	-	46	10.8
CG_Well	30/11/2016	5.64	217	29.9	40	7.2
CG_Well	05/01/2017	5.58	66	-	79	3.6
CG_Well	02/02/2017	7.6	104.9	100.7	54	10.2
CG_PZ_S	14/01/2016	5.9	235	-	93	6
CG_PZ_S	10/02/2016	5.04	403	28.7	35	6.8
CG_PZ_S	08/03/2016	5.98	404	27.4	37	7.7
CG_PZ_S	04/05/2016	6.45	436	-	-14	10.7
CG_PZ_S	01/08/2016	5.68	432	48.4	-4	16.9
CG_PZ_S	27/10/2016	6.35	404	30	16	12
CG_PZ_S	30/11/2016	5.95	448	14.2	-4	9
CG_PZ_S	04/01/2017	6.21	496	-	-1	7.4
CG_PZ_S	02/02/2017	6.64	448.5	102.9	-25	10.1
CG_PZ_N	14/01/2016	6.49	164	-	185	3.9
CG_PZ_N	10/02/2016	6.01	198	31.4	37	4.5
CG_PZ_N	08/03/2016	6.53	213	25.3	76	7.4
CG_PZ_N	04/05/2016	6.34	160	-	-38	12.1
CG_PZ_N	04/01/2017	6.5	360	-	-48	8
CG_PZ_N	02/02/2017	7	313.8	100.9	-45	10.3
CG_PZ_W	14/01/2016	6.93	170	-	216	3.3
CG_PZ_W	10/02/2016	4.98	150	57.7	129	4.6
CG_PZ_W	08/03/2016	6.17	152	16.1	15	8.1
CG_PZ_W	04/05/2016	5.71	156	-	7	12
CG_PZ_W	27/10/2016	7.38	127	28	-	13.2
CG_PZ_W	30/11/2016	6.22	290	30.7	-17	7.4
CG_PZ_W	04/01/2017	6.29	311	-	-15	7.9
CG_PZ_W	02/02/2017	6.8	308.4	101.3	-36	10.5
CG_PZ_POB	14/01/2016	6.07	371	-	69	-
CG_PZ_POB	10/02/2016	5.43	530	31.1	-51	6.8
CG_PZ_POB	04/05/2016	5.68	459	-	21	9.2
CG_PZ_POB	01/08/2016	6.29	470	76.2	-45	16
CG_PZ_POB	27/10/2016	7.66	640	18.2	-	12.6
CG_PZ_POB	30/11/2016	7.16	600	18.2	-107	10.1
CG_PZ_POB	04/01/2017	6.9	566	-	-51	8.8
CG_PZ_POB	02/02/2017	7.27	318.7	102.2	-77	10.5
RGMBH7	15/12/2015	8.3	413	-	-	-

Sample ID	Date	pH	EC	DO	Redox	Temperature
		pH Units	µS/cm	%	mV	°C
RGMBH7	28/04/2016	7.98	471	-	-	-
RGMBH7	04/08/2016	7.72	472	-	-	-
RGMBH7	27/10/2016	7.64	463	-	-	-
RGMBH7	03/02/2017	7.84	452	-	-	-
RGMBH13	15/12/2015	7.64	394	-	-	-
RGMBH13	28/04/2016	7.19	350	-	-	-
RGMBH13	04/08/2016	7.05	519	-	-	-
RGMBH13	27/10/2016	7.54	418	-	-	-
RGMBH13	03/02/2017	7.18	383	-	-	-

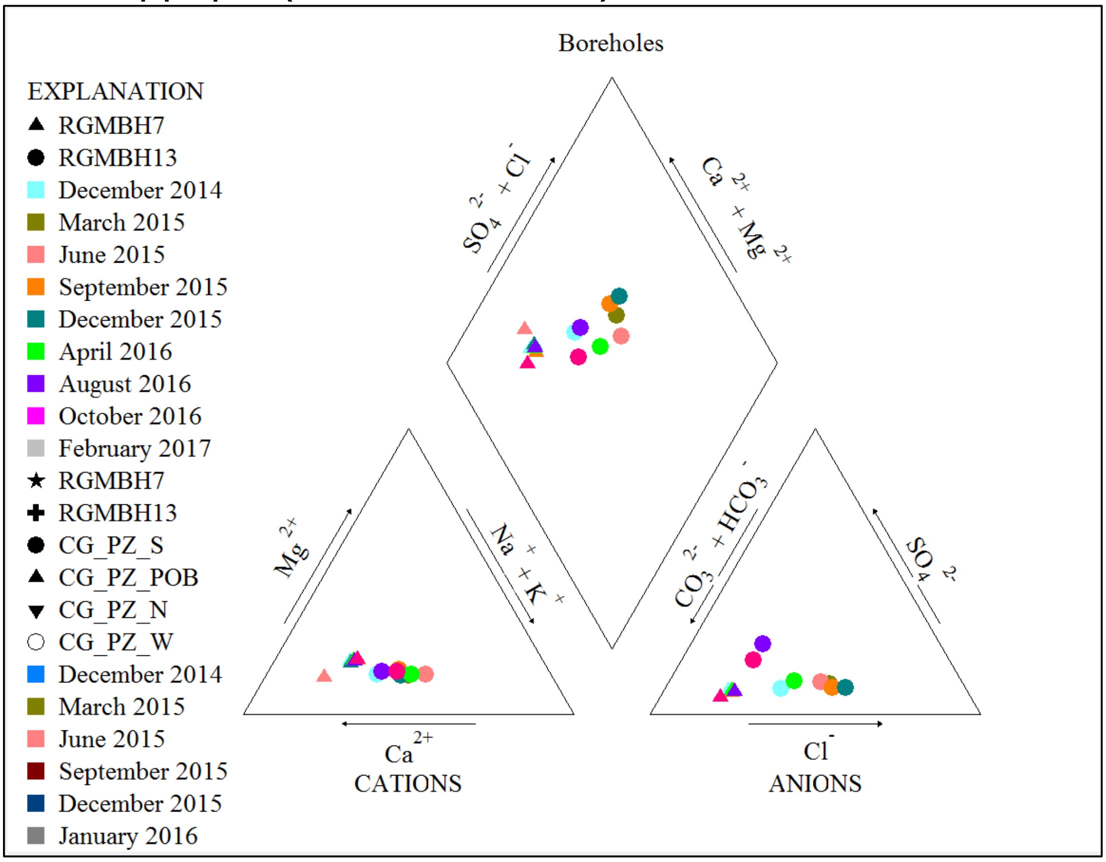
H.2 Water quality laboratory results

Sample ID	Date	pH	EC	Alkalinity (Carbonate)	Alkalinity (Bicarbonate)	Alkalinity (Total)	Total Dissolved Solids	Ammoniacal Nitrogen as N	Chloride	Nitrite as NO2	Nitrate as NO3	Phosphorous (Total)	Phosphate as PO4	Sulphate	Calcium	Iron	Magnesium	Potassium	Sodium	Total Suspended Solids
		pH Units	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CG_S	03/11/2015	5.45	33	<2	5	5	226	0.626	71.6	<1	<0.3	-	-	63.1	19.5	0.347	7.65	2.7	37.5	1060
CG_S	16/12/2015	7.01	182	<2	11	11	175	<0.2	48	<0.05	<0.3	-	-	<2	6.26	2.01	3.51	2.46	21.8	9
CG_Pob	16/12/2015	7.03	277	<2	55	55	258	<0.2	45.7	<0.05	20.4	-	-	<2	25.4	0.155	6.42	4.41	18.9	<2
CG_Pob	04/05/2016	6.81	35	<2	140	140	345	0.608	31.9	<0.5	<0.3	16000	0.26	<10	39.3	6.08	6.88	2.57	14	3440
CG_Pob	27/10/2016	7.39	626	<2	210	210	395	0.281	46.6	<0.05	<0.3	1570	<0.05	94	83	4.44	10.9	6.08	29	2430
CG_Outfall	03/11/2015	7.18	447	<2	120	120	334	7.19	71.7	<0.05	13.3	-	-	41	43.5	0.102	10.4	4.1	35	2580
CG_Outfall	14/01/2016	7.91	305	<2	70	70	182	<0.2	43.8	<0.05	3.14	-	-	<2	24	0.312	5.47	2.54	20.5	3
CG_Outfall	08/03/2016	7.7	308	<2	-	-	225	-	65.3	<0.05	1.46	51.1	<0.05	9.8	-	-	-	-	-	10
CG_Outfall	26/04/2016	7.17	405	<2	100	100	278	<0.2	67.9	<0.05	1.9	922	<0.05	23.2	33.9	0.399	8.72	1.57	28	456
CG_Outfall	01/08/2016	6.66	507	<2	160	160	358	<0.2	78.7	<0.05	<0.3	11300	0.26	21.5	44.6	3.27	12.5	4.03	36	2110
CG_Outfall	16/12/2015	6.98	277	<2	60	60	214	0.202	46.2	<0.05	2.46	-	-	9.6	25.4	0.306	5.45	2.94	21.3	7
CG_Outfall	10/02/2016	7.6	349	<2	105	105	238	<0.2	53.2	<0.05	3.82	36.2	<0.05	17.2	32.9	0.293	8.21	2.45	24.8	6
CG_Outfall	27/10/2016	7.27	338	<2	95	95	225	<0.2	59.6	<0.05	1.35	483	0.06	<2	30.8	1.11	7.86	1.96	31.2	106
CG_Outfall	02/02/2017	7.24	374	<2	95	95	242	<0.2	59.1	<0.05	7.11	89.6	<0.05	19.6	41.3	0.252	19.9	3.72	34.8	19
CG_ODrain	03/11/2015	7.29	596	<2	175	175	531	2.27	66.2	<0.05	<3	-	-	67.3	73.3	11.1	15.5	15.3	41.2	181
CG_ODrain	02/02/2017	7.28	38	<2	105	105	259	<0.2	51.1	<0.05	13.1	182	<0.05	25.7	47.3	0.247	8.65	3.77	26.8	22.5
CG_NPond	03/11/2015	6.79	415	<2	33	33	326	1.58	88.8	0.17	<3	-	-	45.5	11.9	0.491	7.45	37.4	34.8	300
CG_NPond	01/08/2016	6.69	382	<2	75	75	431	6.3	82.3	<0.25	<0.3	1020	2.46	<2	9.45	6.43	5.76	28.9	35.9	2330
CG_NPond	16/12/2015	6.5	186	<2	6	6	140	0.33	51.7	<0.05	1.31	-	-	<2	4.85	0.664	3.37	3.28	24.2	3
CG_NPond	08/03/2016	7.1	153	<2	-	-	137	-	43.1	<0.25	<0.3	88.3	0.059	<2	-	-	-	-	-	<4
CG_NPond	10/02/2016	6.26	173	<2	4.5	4.5	140	<0.2	53	<0.05	2.46	69.3	0.09	11.8	3.73	0.447	2.85	2.18	24.6	2.5
CG_NPond	27/10/2016	7.24	533	<2	135	135	397	14.4	75.5	<0.05	<1.5	4720	6.72	<10	12.2	4.23	8.19	43.2	36.4	110
CG_NPond	02/02/2017	6.52	196	<2	17	17	161	0.934	50.7	<0.05	0.512	586	1.02	<2	6.26	1.66	3.77	5.34	27.4	9.53
CG_SDrain	10/02/2016	7.71	232	<2	44	44	149	<0.2	46.9	<0.05	0.787	38.8	<0.05	<2	16.4	0.0849	3.88	1.01	23.9	14
CG_SDrain	27/10/2016	7.04	213	<2	37	37	148	<0.2	49.2	<0.05	<0.3	1030	<0.05	<2	13.4	0.273	3.67	<1	26.6	996
CG_SDrain	02/02/2017	7.49	324	<2	55	55	213	<0.2	69.8	0.059	<0.3	37.3	<0.05	<2	23.1	0.14	9.12	2.94	42.5	13.6
CG_Road	10/02/2016	7.83	345	<2	95	95	232	<0.2	56	<0.05	2.33	25.6	<0.05	12.1	32	0.044	5.84	1.09	29.5	6
CG_Road	27/10/2016	7.85	371	<2	110	110	402	<0.2	49	<0.05	1.14	52.6	<0.05	19.3	39.1	<0.019	6.25	<1	28.5	20
CG_Road	02/02/2017	7.62	461	<2	100	100	287	<0.2	86.3	<0.05	4.88	60.9	<0.05	18.9	43.9	0.068	7.6	1.59	48.7	24.3
CG_WDrain	08/03/2016	7.32	338	<2	-	-	301	-	65.9	<0.25	10.5	2800	0.092	16.7	-	-	-	-	-	1910
CG_WDrain	10/02/2016	6.47	223	<2	7.5	7.5	167	<0.2	61.5	<0.05	1.95	396	<0.05	6.9	5.34	0.351	3.9	4.36	30.2	151
CG_WDrain	02/02/2017	6.77	424	<2	50	50	299	0.764	82.3	0.139	15	125	0.058	32	15.1	0.691	7.28	30.4	41.7	124
CG_Well	10/02/2016	6.72	109	<2	19.5	19.5	94.4	<0.2	24.3	<0.05	<0.3	336	<0.05	<2	6.08	0.284	2.04	<1	13.8	126
CG_Well	02/02/2017	5.96	117	<2	20	20	55.6	<0.2	23.5	<0.05	<0.3	1210	<0.05	<2	7.62	0.676	2.33	<1	14.9	2100
CG_PZ_S	04/05/2016	6.27	291	<2	100	100	306	0.559	52.5	<0.05	<0.3	304	<0.05	<10	29.7	15.2	7.87	<1	21.7	408
CG_PZ_S	08/03/2016	6.66	368	<2	-	-	361	-	54.5	<0.05	<0.3	131	<0.05	<20	-	-	-	-	-	220
CG_PZ_S	01/08/2016	6.31	268	<2	85	85	273	<0.2	5.3	<0.05	<0.3	89.8	<0.05	<2	24.8	35.5	6.56	<1	22.9	135
CG_PZ_S	14/01/2016	6.04	225	<2	28	28	166	<0.2	55.6	<0.5	<0.3	-	-	<2	14.2	1.99	4.52	<1	18.5	464

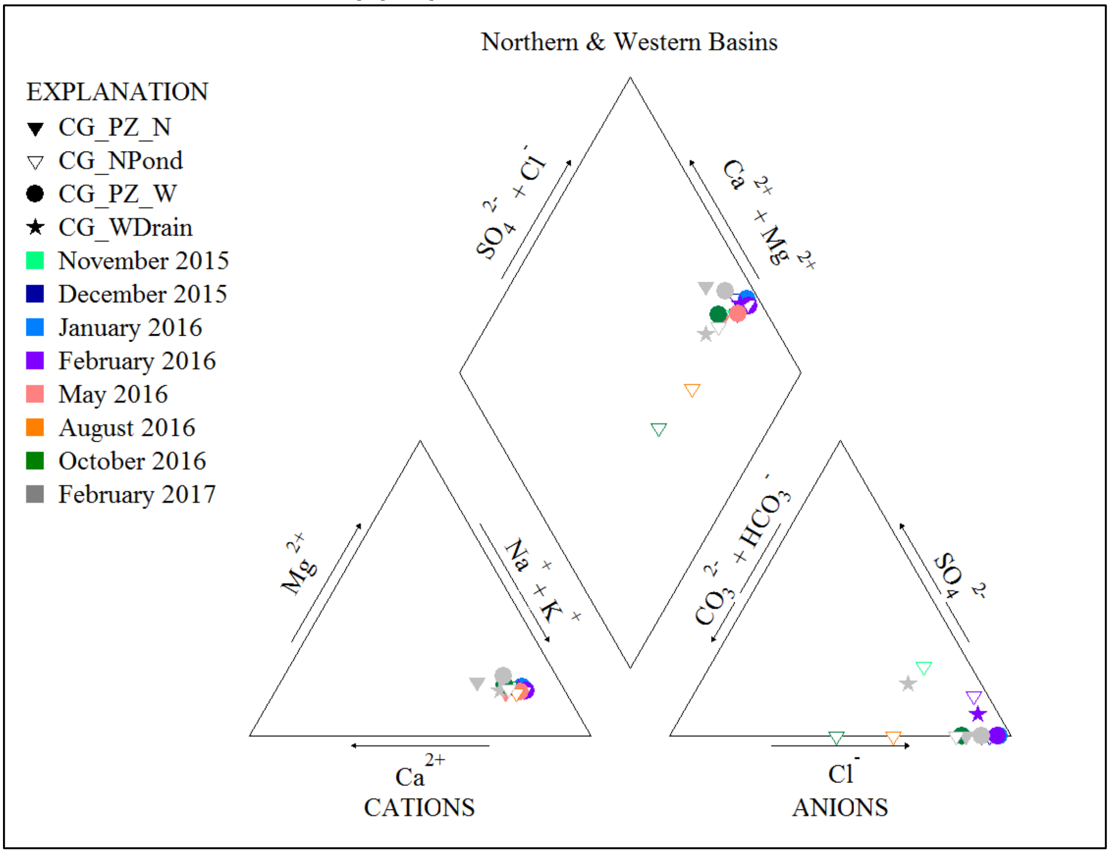
Sample ID	Date	pH	EC	Alkalinity (Carbonate)	Alkalinity (Bicarbonate)	Alkalinity (Total)	Total Dissolved Solids	Ammoniacal Nitrogen as N	Chloride	Nitrite as NO2	Nitrate as NO3	Phosphorous (Total)	Phosphate as PO4	Sulphate	Calcium	Iron	Magnesium	Potassium	Sodium	Total Suspended Solids
		pH Units	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CG_PZ_S	10/02/2016	6.05	29	<2	60	60	237	<0.2	55.5	<0.05	<0.3	272	<0.05	<2	26.6	16.6	7.45	<1	22.1	406
CG_PZ_S	27/10/2016	6.36	289	<2	80	80	301	<0.2	58.9	<0.05	<0.3	79.8	<0.05	<2	25.4	52.6	6.82	<1	22.3	188
CG_PZ_S	02/02/2017	6.17	31	<2	110	110	221	<0.2	58.7	<0.05	<0.3	274	<0.05	<2	30	68.4	8.08	<1	22.2	267
CG_PZ_N	04/05/2016	5.74	15	<2	12.5	12.5	127	0.434	43	<0.05	<0.3	1070	<0.05	<2	4.62	0.834	2.29	<1	20.3	892
CG_PZ_N	08/03/2016	5.81	161	<2	-	-	143	-	46.5	<1	<0.3	1820	0.051	<2	-	-	-	-	-	1920
CG_PZ_N	14/01/2016	6.35	164	<2	7	7	126	0.26	42.9	<0.5	1.07	-	-	<2	3.45	0.436	2.7	3.15	20.4	6
CG_PZ_N	10/02/2016	6	172	<2	8	8	150	<0.2	48.1	<0.05	0.639	595	0.691	<2	4.01	0.499	2.99	2.92	23.9	96
CG_PZ_N	02/02/2017	5.88	204	<2	15.5	15.5	162	0.573	57.7	<0.05	<0.3	692	0.076	<2	11.8	47.1	5.37	3.48	30.1	370
CG_PZ_W	04/05/2016	5.32	142	<2	7	7	130	<0.2	43.9	<0.05	<0.3	4180	<0.05	<2	3.18	1.6	2.22	<1	20	4400
CG_PZ_W	08/03/2016	6.74	136	<2	-	-	103	-	36.4	<1	<0.3	2750	<0.05	<2	-	-	-	-	-	1680
CG_PZ_W	14/01/2016	5.08	127	<2	2	2	106	<0.2	32.8	<0.5	0.924	-	-	<2	2.38	0.372	2.01	1.25	15.8	248
CG_PZ_W	10/02/2016	5.32	147	<2	3	3	129	<0.2	40.9	<0.5	0.398	670	<0.05	<2	2.9	1.43	2.39	1.43	20.8	456
CG_PZ_W	27/10/2016	5.76	11	<2	8	8	178	<0.2	27.6	<0.05	<1.5	2480	<0.05	<10	3.47	18	2.22	<1	15.9	910
CG_PZ_W	02/02/2017	5.54	174	<2	7.5	7.5	174	<0.2	47.3	<0.05	1.07	496	<0.05	<2	5.04	19.6	3.98	<1	23.9	109
CG_PZ_POB	04/05/2016	7.52	471	<2	225	225	316	<0.2	43.7	<0.05	<0.3	2220	<0.05	<2	66.7	<0.019	8.06	<1	25.3	3920
CG_PZ_POB	08/03/2016	7.58	502	<2	-	-	358	-	43.4	<0.05	<0.3	1460	<0.05	<2	-	-	-	-	-	2090
CG_PZ_POB	01/08/2016	7.13	598	<2	275	275	383	34.3	42	<0.05	<0.3	6180	0.062	<2	60.9	6.78	7.59	4.47	21.8	2430
CG_PZ_POB	14/01/2016	7.27	262	<2	55	55	200	<0.2	41.2	0.079	11.6	-	-	<2	20.3	0.199	5.79	9.18	17.8	274
CG_PZ_POB	10/02/2016	7.53	355	-	-	-	-	1.27	45.2	<0.5	1.64	-	-	30.5	-	-	-	-	-	-
CG_PZ_POB	02/02/2017	7.33	493	<2	200	200	1810	0.348	44.1	0.127	<0.3	797	<0.05	31.1	81.1	30.2	9.32	<1	27.9	1990
RGMBH7	15/12/2015	8.3	413	<2	185	185	292	<0.3	40.2	0.036	3.52	-	-	20.3	58.6	<0.019	11	<1	27	136
RGMBH7	28/04/2016	7.98	471	<2	190	190	319	<0.3	38.8	0.097	15.6	-	-	21.4	55	<0.019	11	<1	26.4	36
RGMBH7	04/08/2016	7.72	472	<2	180	180	316	<0.3	39.4	0.125	15.9	-	-	19.3	57.7	<0.019	11.4	<1	28.2	26.5
RGMBH7	27/10/2016	7.64	463	<2	235	235	290	<0.3	40.4	0.139	15.3	-	-	18.1	55.8	<0.019	11.7	<1	28.3	262
RGMBH7	03/02/2017	7.84	452	<2	185	185	301	<0.3	39.2	0.113	14.8	-	-	19.4	-	<0.019	12.8	1.05	28.7	106
RGMBH13	15/12/2015	7.64	394	<2	75	75	241	<0.3	81.4	<0.015	2.21	-	-	18.8	35.4	<0.019	6.49	4.41	34	66.4
RGMBH13	28/04/2016	7.19	350	<2	95	95	224	<0.3	50.6	<0.05	4.91	-	-	20.7	28.6	<0.019	5.77	3.37	32.2	45
RGMBH13	04/08/2016	7.05	519	<2	110	110	381	0.635	31.5	0.268	92.1	-	-	48.3	50.7	<0.019	9.15	3.9	37.3	19
RGMBH13	27/10/2016	7.54	418	<2	130	130	298	<0.3	34.2	<0.05	36.1	-	-	40.3	34.6	<0.019	6.75	3.4	31.7	744
RGMBH13	03/02/2017	7.18	383	<2	75	75	266	0.379	70.9	0.66	8.99	-	-	28.9	-	0.363	7.16	3.67	33.7	40.8

H.3 Piper plots

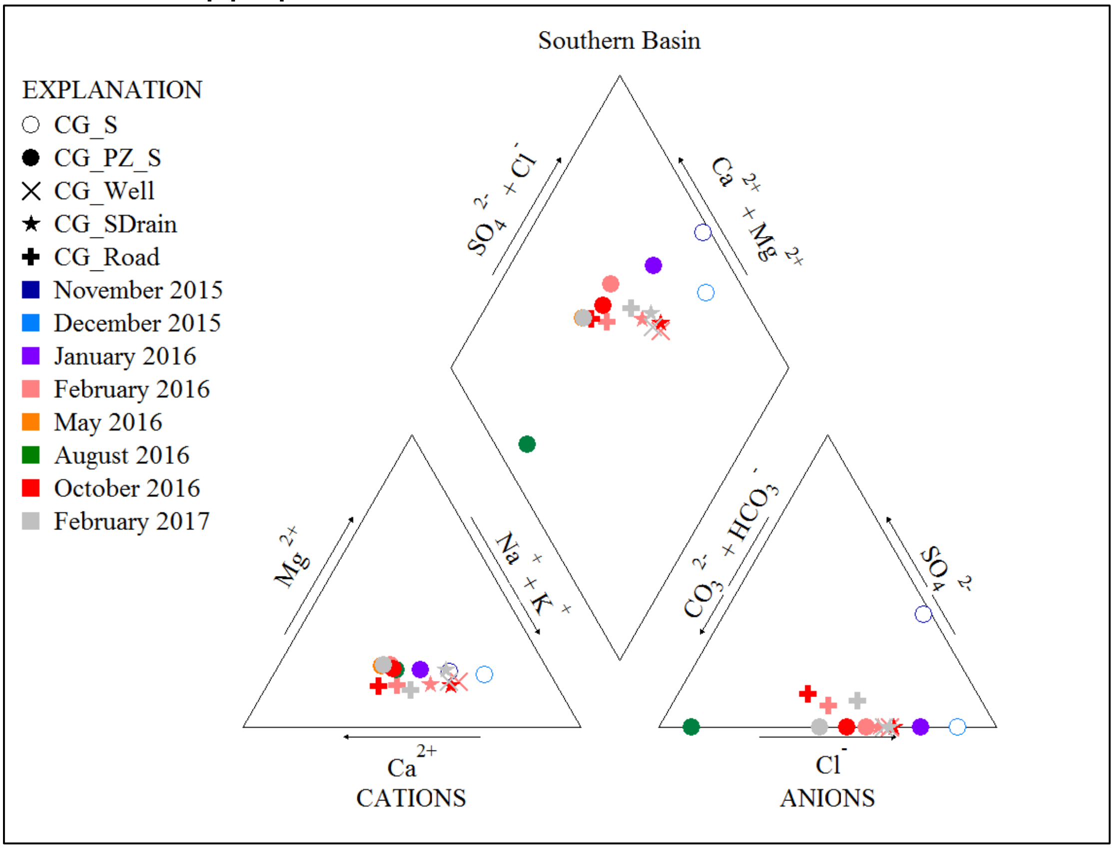
Boreholes piper plots (RGMBH7 and RGMBH13)



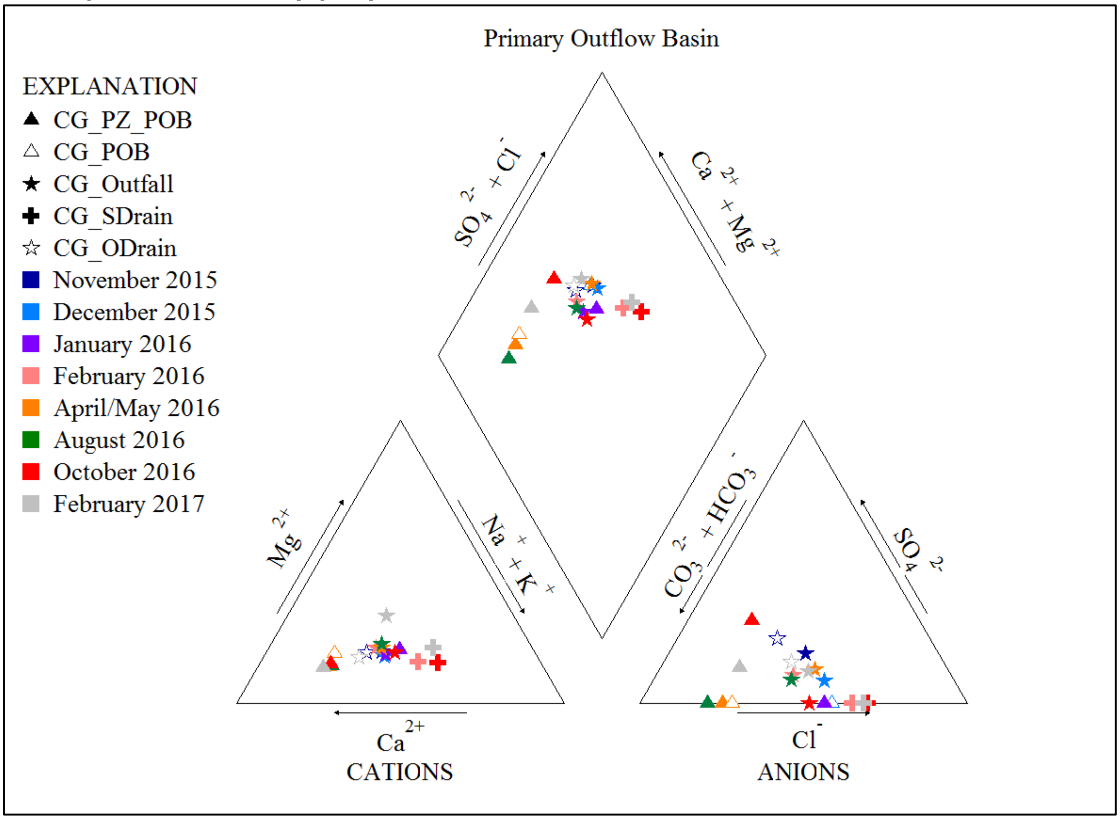
Northern & Western Basins piper plots



Southern Basin piper plots



Primary Outflow Basin piper plots



Borehole and Piezometer piper plots