Technical Appendix 4: Flood Consequence Assessment and Drainage Strategy

Penpergwm Solar Farm

06/05/2021

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Contents

STATEMENT OF PURPOSE

4.1. *This draft Flood Consequence Assessment and Drainage Strategy is being published to accompany pre-application consultation carried out under Articles 8 and 9 of the Development of National Significance (Procedure) (Wales) Order 2016. The formal pre-application consultation runs until 25th August 2021.*

EXECUTIVE SUMMARY

4.2. This Flood Consequence Assessment (FCA) and Drainage Strategy (DS) has been carried out for the Proposed Development consisting of a proposed solar farm and associated infrastructure lands circa 0.5km north of Penpergwm and c. 3.9km southeast of Abergavenny, Monmouthshire.

4.3. According to the Development Advice Map, the Application Site is wholly situated within Flood Zone A, except for a small area within Field 4, which is Flood Zone B. However, this area has been avoided of development and therefore the Proposed Development is wholly within Flood Zone A. In accordance with Technical Advice Note 5, the Application Site is situated in an area that that is at little or no risk of fluvial or tidal/coastal flooding. Consequently, a justification test was not required for the Proposed Development, however a Drainage Strategy was required to ensure that the Proposed Development will not increase flooding elsewhere.

4.4. In addition to fluvial and coastal flood risk, Natural Resources Wales also provide surface water flood maps. This indicated that the small watercourse to the north of Field 1, 3 and 4, as well as the watercourse which dissects Fields 10 and 11 have some minor flood risk issues, however they look to be contained within the watercourse's banks.

4.5. Where the Natural Resources Wales map demonstrated areas of surface water risk, the topographical survey, as well as aerial maps, were studied to determine if there will indeed be surface water flooding within the Application Site. The watercourses where the surface water issues are located did not appear to have any evidence of out of bank flooding during the site visit. The topographical survey also shows they are well defined and have a gradient which would clearly move water through the watercourses and away from the Proposed Development. There is no electrical infrastructure within 8m of these two watercourses with potential surface water flood risks, only tracks and fencing.

4.6. It has been demonstrated that the Proposed Developments impact on surface water runoff is minimal due to the small amount of impermeable infrastructure (0.28% of the overall Application Site Area) proposed for the Application Site. However, drainage in the form of Sustainable Drainage Systems (SuDS) has been proposed so the post developed site discharges surface water at the greenfield run off rate (QBar). Due to large area of the Grid Substation, and the dispersed nature of the impermeable development of the rest of the Proposed Development, drainage schemes for these have been designed separately.

4.7. Soil permeability testing was undertaken to the north of where the grid substation is being located within Field 3 of the Application Site. The soil description at this location is described as '*Reddish brown sandy, gravelly CLAY. Sand is fine - medium. Gravel is medium - coarse, angular of mixed lithology*'. The soils encountered beneath the site were found to be predominantly CLAY, which contradicts the Soilscapes maps in this location. The soakage rates obtained during the investigation were found to be practically impermeable. Given the data

from the test, it is considered that soakaways are not suitable at the grid substation location. Further testing will be undertaken at the soakaway channels/ filter drain's locations prior to the construction period to determine whether these locations are suitable for infiltration.

Proposed Drainage Strategy (Solar Farm)

4.8. It is proposed to construct six soakaway channels/ filter drains within the Application Site. The location of the channels has been chosen to intercept flows before they enter the existing drainage system surrounding the site.

4.9. The proposed soakaways will have an overall combined length of approximately 1,243m, with a base width of 0.5m, a 0.5m design depth and a 0.15m freeboard. They will be filled with crushed rock with a void ratio of 20%.

4.10. It will provide a total storage volume of approximately 62.2m^3. This is greater than the volume of additional runoff generated as a result of the impermeable buildings (31.0m^3). It is therefore considered that this adequately mitigates the increase in flow rates as a result of the minor increase in impermeable area and provides improvement.

Proposed Drainage Strategy (Grid Substation)

4.11. It is proposed that surface run-off will be collected and conveyed by the provision of filter drains to a detention basin. A notional freeboard level of 150mm shall be incorporated into the detention basin for the 1 in 100-year storm event with the final design of the pond being submitted for Sustainable Drainage Approving Body (SAB) approval prior to the construction period. The design volume of the detention basin will be a minimum of 131m^3.

4.12. As stated previously, the grid substation area is underlain by clays which exclude infiltration techniques for surface water disposal. QBAR discharge rate restriction satisfies the requirements of the SuDS Manual '*Designing for Long Term Storage*'. Final discharge is restricted at the pond by the provision of a Hydro-Brake® vortex flow control device, or a device of similar quality.

4.13. The discharge point will be into the existing site field drainage to the north west of the detention basin.

4.14. Additional drainage measures to be implemented on-site include the following:

- Solar Panels: current grass cover is to be retained or reinstated adjacent to and under panels in order to maximise bio-retention;
- Access Tracks: access tracks are to be unpaved and constructed from local stone. Temporary swales or similar shall be utilised to collect runoff from access tracks with discharge to ground through percolation areas. Where swales are utilised, frequent

check dams formed from gravels and other excavated material should be undertaken; and

- **Transformer Stations:** the scale of these types of structures is unlikely to warrant a formalised drainage system. Runoff from this infrastructure and any associated hard standing should be directed to a percolation area for discharge to ground. Should surface water accumulate around any of these locations then a simple soakaway can be constructed to allow water soak into the underlying subsoils.

4.15. The FCA and DS has therefore demonstrated that the Proposed Development will **not increase flood risk** away from the Application Site during the construction, operation and decommissioning phases. The Proposed Development is therefore considered to be acceptable in planning policy terms.

INTRODUCTION

Background

4.16. Neo Environmental Ltd have been appointed by Great House Energy Centre Limited (the "Applicant") to complete a flood consequence assessment and drainage strategy ("FCA" & "DS") for a proposed solar farm and associated infrastructure (the "Proposed Development") on land 0.5km north of Penpergwm and c. 3.9km southeast of Abergavenny, Monmouthshire (the "Application Site").

4.17. Please see **Figure 4 of Volume 2: Planning Application Drawings** for the layout of the Proposed Development.

Development Description

4.18. The Proposed Development consists of the construction of a 40MW solar farm and will comprise PV panels mounted on metal frames, inverter and transformer units, new access tracks, underground cabling, perimeter fencing with CCTV cameras and access gates, a temporary construction compound and all ancillary grid infrastructure and associated works.

Site Description

4.19. The Application Site is located on land 0.5km north of Penpergwm and c. 3.9km southeast of Abergavenny, Monmouthshire; the approximate centre point of which is Grid Reference E332954, N211435. Comprising 14 agricultural fields, the Application Site measures 70.03 hectares (ha) in total with only c. 17.61 hectares of the landscape under the solar arrays themselves. See **Figure 4 of Volume 2: Planning Application Drawings** for details.

4.20. Land within the Application Site itself is undulating, ranging between 61 – 140m Above Ordnance Datum (AOD) and consists of fields typically of medium scale, bound by a mixture of grassy field margins, semi-mature hedgerows, and intermittent trees (see **Figure 3 of Volume 2: Planning Application Drawings** for field numbers).

4.21. The Application Site is in an area with existing electricity infrastructure with a pylon line crossing Field 3 to the north and running in a north – south direction between Fields 6 and 7 and to the west of Field 8.

4.22. The local area is largely agricultural in nature, punctuated by individual properties and farmsteads; the nearest residential areas are the villages of Penpergwm and The Bryn; located 0.5km and 0.9km north respectively. and Yeomadon, located 0.7km northeast and southeast respectively. Recreational Routes include two Public Rights of Way (PRoW) which pass through Fields 8, 9, 10 and 11 in the southern section of the site and an Other Route with Public Access (ORPA) which passes from Great House along the eastern boundary of Field 14

and through the treeline on the southern border of Fields 5, 6 and 7. Another PRoW passes along the northern boundary of Fields 1, 3 and 4.

4.23. While there are a number of drains and watercourses throughout the Application Site, including a small tributary of the Frwd Brook bordering Field 11, the site is entirely contained within Flood Zone A, an area described as having a "*Low probability*" of flooding.

4.24. The Application Site will be accessed via an improved farm access situated on the southern boundary. Traffic will approach the site entrance from the south using a local road from Penpergwm for approximately 800m. Traffic will be routed to Penpergwm from the north via the B4598. This road connects to the strategic road network south of Abergavenny at the A40 / A465 interchange.

Scope of Report

4.25. The aim of this assessment is to identify the baseline geological and hydrological conditions of the site and surrounding area; to assess the potential impacts of the Proposed Development during the construction, operation and decommissioning phases; to identify the risk of flooding at the proposed Application Site; and to recommend mitigation measures where appropriate.

4.26. This report is supported by the following figures and appendices:

- Appendix 4A Figures:
  - Figure 4.1: Watercourses Map;
  - Figure 4.2: Topographical Survey
  - Figure 4.3: Development Advice Map
  - Figure 4.4: Flood Risk Map
  - Figure 4.5: Outline SuDS Design (Solar Farm)
  - Figure 4.6: Outline SuDS Design (Grid)
- Appendix 4B: Flow Output (Solar Farm)
- Appendix 4C: Flow Output (Grid Substation)
- Appendix 4D: BRE 365 Test and Report

Statement of Authority:

4.27. This FCA & DS has been produced by Michael McGhee of Neo Environmental. Having completed a civil engineering degree in 2012, Michael has worked on over 1GW of renewable development flood risk assessments across the UK and Ireland whilst working towards becoming a Chartered Engineer. Michael has over 10 years of environmental consultancy experience, mainly producing technical assessments for energy projects.

LEGISLATION

4.28. A review of relevant legislation has been conducted to ensure the Proposed Development complies with the following:

- EU Directive on the Assessment and Management of Flood Risks [2007/60/EC][1] implemented in Wales via the Flood and Water Management Act 2010[2] and the Flood Risk Regulations 2009[3];
- The Water Framework Directive [2000/60/EC][4] as implemented in Wales via the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017[5];
- The Groundwater Directive (GWD) (2006/118/EC)[6] as implemented by the Groundwater (Water Framework Directive) (Wales) Direction 2016 and Environmental Permitting (England and Wales) Regulations 2016.
- Future Wales – the National Plan 2040 (NP)[7]
- Planning Policy Wales 11th Edition (PPW), 2021[8]

[1] European Parliament (2007). Directive 2007/60/EC of the European Parliament and of the Council establishing a framework for the assessment and management of flood risks. Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32007L0060

[2] UK Government (2010). Flood Water a Management Act 2010. Available at https://www.legislation.gov.uk/ukpga/2010/29/contents

[3] UK Government (2009). The Flood Risk Regulations 2009. Available at http://www.legislation.gov.uk/uksi/2009/3042/contents

[4] European Parliament (2000). Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy ("The Water Framework Directive"). Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32000L0060.

[5] UK Government (2017). The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017. Available at http://www.legislation.gov.uk/uksi/2017/407/contents/made

[6] European Parliament (2006). Directive 2006/118/EC of the European Parliament and of the Council establishing a framework for the protection of groundwater against pollution and deterioration ("The Water Framework Directive"). Available athttps://www.eea.europa.eu/policy-documents/groundwater-directive-gwd-2006-118-ec

[7] Ministry of Housing, Communities & Local Government, National Planning Policy Framework, Feb 2019. Available at https://gov.wales/sites/default/files/publications/2021-02/future-wales-the-national-plan-2040.pdf

[8] Wales Government, Planning Policy Wales 11th Edition, 2021, Available at https://gov.wales/sites/default/files/publications/2021-02/planning-policy-wales-edition-11_0.pdf

- Technical Advice Note 15: Development and Flood Risk (TAN15), 2004[9]
- Sustainable Drainage (SuDS) Statutory Guidance[10]

Future Wales – the National Plan 2040 (NP)

4.29. Future Wales – the National Plan 2040 (NP)[11] is the national development framework, setting the direction for development in Wales to 2040. It is a development plan with a strategy for addressing key national priorities through the planning system, including sustaining and developing a vibrant economy, achieving decarbonisation and climate-resilience, developing strong ecosystems and improving the health and well-being of our communities.

4.30. Policy 8 (Flooding) states that '*the Welsh Government will work with Flood Risk Management Authorities and developers to plan and invest in new and improved infrastructure, promoting nature-based solutions as a priority*'. It goes on to state that '*it must be ensured that projects do not have adverse impacts on international and national statutory designated sites for nature conservation and the features for which they have been designated*'.

4.31. This report takes into account this policy and will ensure the no adverse impacts on international and national statutory designated sites will occur.

Planning Policy Wales (PPW): Edition 11

4.32. Planning Policy Wales (PPW) Edition 11 was adopted by the Welsh Government in February 2021. This replaced the previously adopted PPW and sets out the land use planning policy for Wales. Chapter 6 of the PPW outlines the planning policy in relation to 'Distinctive and Natural Places'. With regards to water and flood risk, it states:

"The Welsh Government aims to secure the provision of water services whilst minimising adverse impacts on the environment, amenity, health and communities, in light of the consequences of climate change. Development which is poorly designed or badly located can exacerbate problems associated with resource depletion, exposure to surface water flooding and diffuse pollution. The planning system should:

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[9] Wales Government, Technical Advice Note 15: Development and Flood Risk, 2004 https://gov.wales/sites/default/files/publications/2018-09/tan15-development-flood-risk.pdf

[10] Welsh Government, Sustainable Drainage (SuDS) Statutory Guidance, 2019, Available at https://www.monmouthshire.gov.uk/app/uploads/2020/01/Statutory-Guidance.pdf

[11] Ministry of Housing, Communities & Local Government, National Planning Policy Framework, Feb 2019. Available at https://gov.wales/sites/default/files/publications/2021-02/future-wales-the-national-plan-2040.pdf

- *protect and improve water resources by promoting and encouraging increased efficiency and demand management of water as part of new developments, particularly in those areas where water resources may be under pressure or may not be available;*
- *ensure that the infrastructure on which communities and businesses depend is adequate to accommodate proposed development so as to minimise risk to human health and the environment and prevent pollution at source;*
- *ensure sustainable drainage systems are an integral part of design approaches for new development; and*
- *ensure the protection of the quantity and quality of surface and ground water supplies is taken into account as part of development proposals.*

4.33. Again, these policy measures have been taken into account in this report and are integral to the design of the Proposed Development.

Review of Local Plan Policy

Monmouthshire Local Plan

4.34. The Monmouthshire County Council Local Development Plan (the "LDP") is the adopted plan at present. With the following policies being relevant to this Flood Consequence Assessment and Drainage Scheme report:

Table 4 - 1: Local Plan Flood Management Policies/Objectives (key points summarised)

Planning Policy/Objective	Comment
Policy S12 *"Efficient Resource Use and Flood Risk* *All new development must:* *• Demonstrate sustainable and efficient resource use – this will include energy efficiency/ increasing the supply of renewable energy, sustainable construction materials/ techniques, water conservation/ efficiency and waste reduction;* *• Avoid the siting of inappropriate development in areas at risk of flooding."*	The flood risk will be assessed in the Flood Consequence Assessment.
Policy SD3	A Flood Consequence Assessment will be

"Proposals for highly vulnerable development or emergency services will not be permitted in areas which may be liable to flooding, unless the residential development is for the conversion of upper floors within defined settlement boundaries or the proposal is to extend an established tourism, leisure or educational establishment. Less vulnerable built development will be permitted within defined settlements or on sites allocated for uses such as employment. Development proposals within a flood plain will be required to demonstrate that: *a) the development is or can be protected by approved engineering works and / or other flood protection measures;* *b) such remedial measures would not cause flooding or significantly increase the risk of flooding elsewhere;* *c) the development, including any remedial measures, can be sympathetically assimilated into the environment in terms of its siting, scale, design and landscaping;* *d) the development does not interfere with the ability of the Environment Agency or other bodies to carry out flood control works or maintenance; and* *e) the nature conservation interest of the water source corridor is protected and, where practicable, enhanced.* *Development resulting in additional surface water run-off and leading to an increased risk of flooding will only be permitted where adequate protection and mitigation measures are included as part of the proposal."*	undertaken to determine the flood risk, and a Drainage Scheme will be produced to ensure run-off levels remain at greenfield rates.
Policy SD4 *"Development proposals will be expected to incorporate water management measures, including Sustainable Urban Drainage Systems (SUDS), to reduce surface water run-off and minimise its contribution to flood risk elsewhere."*	A Drainage Scheme will be undertaken to develop suitable SuDS.

4.35. This report also considers the following local assessments and plans:

- Preliminary Flood Risk Assessment (PFRA)[12]
- Addendum to the Preliminary Flood Risk Assessment[13]
- Flood Risk Management Strategy[14]
- Flood Risk Management Plan[15]

[12] Monmouthshire County Council (2011). Preliminary Flood Risk Assessment for Monmouthshire Available at https://www.monmouthshire.gov.uk/app/uploads/2018/02/Preliminary-Flood-Risk-Assessment-2011.pdf

[13] Monmouthshire County Council (2017), Preliminary flood risk assessment Addendum: Monmouthshire County Council, Available at https://www.monmouthshire.gov.uk/app/uploads/2018/02/Preliminary-Flood-Risk-Assessment-Addendum-2017.pdf

[14] Monmouthshire County Council, Local Flood Risk Management Strategy (April 2013) Available at: https://www.monmouthshire.gov.uk/app/uploads/2018/02/Local-Flood-Risk-Management-Strategy-2013.pdf

[15] Monmouthshire County Council, Flood Risk Management Plan (February 2016) Available at: https://www.monmouthshire.gov.uk/app/uploads/2018/02/Flood-Risk-Management-Plan-2016.pdf

METHODOLOGY

4.36. PPW 11th Edition was published in January 2021 and outlines the flood risk to developments under the "Development and Flood Risk" section. It states:

"Development Advice Maps enable planning authorities to take a strategic approach to flood risk and consider the catchment as a whole by providing a preliminary representation of flood risks, which inform decisions on the location of new development and the requirements necessary to support any applications which may be proposed. Together with flood consequences assessments they should assist understanding of how natural and man-made defences work as integral components of places and provide a means by which the cumulative effects of development can begin to be understood

Development should reduce, and must not increase, flood risk arising from river and/or coastal flooding on and off the development site itself. The priority should be to protect the undeveloped or unobstructed floodplain from development and to prevent the cumulative effects of incremental development.

In areas of flood plain currently unobstructed, where water flows in times of flood, built development should be wholly exceptional and limited to essential transport and utilities infrastructure. Such infrastructure should be designed and constructed so as to remain operational even at times of flood, to result in no net loss of floodplain storage, to not impede water flows and to not increase flood risk elsewhere. TAN 15: Development and Flood Risk should be referred to for further policy advice on development and flood risk. It will be important to note that developments located within flood risk areas remain at risk from flooding even if mitigation measures are applied."

4.37. TAN15 is used in conjunction with PPW to set out the technical guidance which supplements the policy set out in PPW, with specific mention towards developments and flooding. The general approach of PPW, supported by the TAN, is to advise caution in respect of new development in areas at high risk of flooding by setting out a precautionary framework to guide planning decisions.

4.38. Table 4 – 2 shows the flood zone classification in detail with each flood zone being outlined for what it can be used for in regard to developments.

Table 4 - 2: Flood Zone Classification

Flood Zone	Description	Use
Zone A	Considered to be at little or no risk of fluvial or tidal/coastal flooding.	Used to indicate that justification test is not

		applicable and no need to consider flood risk further
Zone B	Areas known to have been flooded in the past evidenced by sedimentary deposits.	Used as part of a precautionary approach to indicate where site levels should be checked against the extreme (0.1%) flood level. If site levels are greater than the flood levels used to define adjacent extreme flood outline there is no need to consider flood risk further.
Zone C	Based on Environment Agency extreme flood outline, equal to or greater than 0.1% (river, tidal or coastal)	Used to indicate that flooding issues should be considered as an integral part of decision making by the application of the justification test including assessment of consequences
Zone C1	Areas of the floodplain which are developed and served by significant infrastructure, including flood defences.	Used to indicate that development can take place subject to application of justification test, including acceptability of consequences.
Zone C2	Areas of the floodplain without significant flood defence infrastructure.	Used to indicate that only less vulnerable development should be considered subject to application of justification test, including acceptability of consequences. Emergency services and highly vulnerable development should not be considered.

4.39. The Guidelines provide three development categories, which are detailed as follows:

- Emergency Services – Must be always operational and accessible.

- Hospitals, Ambulance Stations, Fire Stations, Police Stations, Coastguard Stations, Command Centres, emergency depots and buildings that provide shelter during floods.

- **Highly Vulnerable – Ability of occupants to decide if they wish to accept the risks associated with flooding or be able to manage the consequences of such a risk, is limited.**

  - All Residential premises (Hotels and Caravan Parks inclusive), Public Buildings (e.g Schools, Libraries, leisure Centres), Especially vulnerable Industrial Development (e.g Power Stations, Chemical Plants, Incinerators) and Waste Disposal Sites.

- **Less Vulnerable - Ability of occupants to decide if they wish to accept the risks associated with flooding is greater than those in the Highly Vulnerable.**

  - General Industrial, Employment, Commercial and Retail Development, Transport and Utilities Infrastructure, Car Parks, Mineral Extraction Sites and associated Processing Facilities.

4.40. The Welsh Government has advised that a Flood Consequences Assessment is not required if a site lies entirely within Flood Zone A. However, for Major Developments (i.e. greater than 1 hectare), where drainage implications can be significant, it suggests that a "Drainage Strategy" report be prepared to support the application, the details of which are set out in the Drainage Strategy chapter of this report.

4.41. The Proposed Development is within Flood Zone A, however is over 1 hectare in size. A Drainage Strategy will be completed, however due to the scale of the project; the baseline conditions and flood risks in the surrounding area will be considered.

BASELINE CONDITIONS

4.42. This section presents the information gathered on the existing topographical, geological, hydrological and hydrogeological conditions of the Application Site and its immediate surroundings.

4.43. A site walkover survey was also undertaken in order to identify hydrological, geological, flood risk and drainage features within the Application Site.

Topography

4.44. A topographical survey was undertaken at the Application Site (see Figure 4.2 Appendix 4A). The lowest point within the Application Site of 61.0m AOD is in the southeast corner of Field 9. The high point at 140m AOD is located near the northwest corner of Field 5. All fields generally have a steady gradient falling away from the high point within Field 5, except near the road within Field 11 which falls away west to the low point in Field 9.

Geology & Soil

4.45. The geological conditions of the Application Site were identified utilising the British Geological Society ("BGS") Spatial Resources online geological mapping[16] system. It is underlain by St Maughans Formation (Argilaceous Rocks, Sandstone) and Raglan Mudstone Formation (Siltstone, Mudstone). St Maughans Formation sedimentary bedrock formed approximately 393 to 419 million years ago in the Devonian Period. Local environment previously dominated by rivers. Raglan Mudstone Formation sedimentary bedrock formed approximately 419 to 424 million years ago in the Silurian Period. The local environment was previously dominated by rivers.

4.46. There are no verified bedrock boreholes located within the proposed Application Site, or within at least 500m of the Application Site.

Soil

4.47. Different soil types have different capabilities of soaking up water, the efficiency of which is dependent upon the structure and infiltration capacity. The Soilscapes[17] map has been utilised to obtain soil data. It classes the soil at the site as '*Freely draining slightly acid loamy soils'* and '*Freely draining floodplain soils'.*

[16] BGS Geology of Britain Map., Available at http://mapapps.bgs.ac.uk/geologyofbritain/home.html

[17] Cranfield Soil and Agrifood Institute, Soilscapes website. Available at http://www.landis.org.uk/soilscapes/

4.48. According to the Wallingford Procedure 'Winter Rain Acceptance Potential' (WRAP) map[18], the soil classification for the site is Class 2. This soil class has a Standard Percentage Runoff (SPR) of 0.3 and will likely provide good infiltration opportunities.

4.49. Soil permeability testing was undertaken to the north of where the grid substation is being located within Field 3 of the Application Site, see **Appendix 4D**. The soil description at this location is described as '*Reddish brown sandy, gravelly CLAY. Sand is fine - medium. Gravel is medium - coarse, angular of mixed lithology*'. The soils encountered beneath the site were found to be predominantly CLAY, which contradicts the Soilscapes maps in this location. The soakage rates obtained during the investigation were found to be practically impermeable. Given the data from the test, it is considered that soakaways are not suitable at the grid substation location. Further testing will be undertaken at the soakaway channels/ filter drain locations prior to the construction period to determine whether they locations are suitable for infiltration.

Hydrology

4.50. The Application Site lies within the Severn River Basin District. Within this, the site lies in the Usk Management Catchment. The River Usk rises on the northern slopes of the Black Mountain and flows in a long narrow catchment of great scenic beauty for approximately 125km south easterly through the towns of Brecon, Crickhowell, Abergavenny and Usk, before discharging to the Usk estuary at Newbridge and then to the Severn estuary at Newport.

4.51. The Application Site is within the River Usk drinking Water Protected Area. The sensitivity of this area from impacts of contamination will be high. During the operational stage of the Proposed Development, there will be a **negligible risk of contamination** due to the benign nature of a solar farm. Any risks will come from the construction stage and an outline Construction and Environmental Management Plan (OCEMP) has been submitted alongside this application in order to reduce any potential impact on the environment during the construction and decommissioning phases of the Proposed Development (see **Technical Appendix 8: Volume 3**).

Local River Network

4.52. The Application Site itself has a number of small watercourse/field drains which lead into the Ffwrd Brook, which leads to the River Usk/Afon Wysg which is located approximately 2.2km to the south and has an overall classification of "moderate" under the Water Framework

[18] UK Sustainable Drainage and Guidance Tools. Greenfield Runoff Estimation for the Sites. Available at: http://www.uksuds.com/greenfieldrunoff_js.htm

Directive (WFD). **Figure 4.1: Appendix 4A** shows the local watercourse network in relation to the Application Site.

Flood Zone Classification

4.53. Welsh Government produced a Development Advice Map (DAM)[19], based off Natural Resource Wales' (NRW) extreme flood outlines and the British Geological Survey drift data). Within the DAM, it shows the Application Site (see **Figure 4.3: Appendix 4A)** to be wholly situated within Flood Zone A, except for a small area within Field 4, which is Flood Zone B. However, this area has been avoided of development and therefore the Proposed Development is wholly within Flood Zone A.

Historic Flooding

4.54. The NRW recorded flood extents[20] is a GIS layer showing the maximum extent of individual recorded flood outlines from rivers, sea or surface water. The map shows that no part of the Application Site has been subject to flooding historically, with the closest area of historic flooding occurring along the River Usk to the south.

4.55. A review of the Strategic Flood Risk Assessments covering the area has confirmed that there are no specific records of flooding within the Application Site.

Hydrogeology

4.56. The Application Site is within the Usk groundwater body defined in the Water Framework Directive which has an overall status of 'Good'. The underground aquifer across the site is classed as a 'low productivity aquifer'.

4.57. The Application Site is not located within any Source Protection Zones, based on NRW mapping.

Groundwater Vulnerability

4.58. Groundwater Vulnerability refers to the intrinsic geological and hydrogeological characteristics that determine the ease at which groundwater may be contaminated by human activities. The more vulnerable the groundwater is, the more easily it can be contaminated by surface water.

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[19] Natural Resources Wales, Development Advice Map, Available at https://maps.cyfoethnaturiolcymru.gov.uk/Html5Viewer/Index.html?configBase=https://maps.cyfoethnaturiolcymru.gov.uk/Geocortex/Essentials/REST/sites/Flood_Risk/viewers/Flood_Risk/virtualdirectory/Resources/Config/Default&layerTheme=2

[20] Natural Resources Wales, Historic Flood Extents, Available at https://lle.gov.wales/catalogue/item/HistoricFl/?lang=en

4.59. According to the British Geological Survey (BGS) maps, the groundwater vulnerability across the Application Site is considered to be 'medium'.

FLOOD CONSEQUENCE ASSESSMENT

Fluvial and Coastal Flood Risk

4.60. Within the DAM (**Figure 4.3: Appendix 4A**), it shows the Application Site to be wholly situated within Flood Zone A, except for a small area within Field 4, which is Flood Zone B. However, this area has been avoided of development and therefore the Proposed Development is wholly within Flood Zone A. Therefore, in accordance with TAN15, the Application Site is situated in an area that that is at little or no risk of fluvial or tidal/coastal flooding. Consequently, a justification test is not required for this Proposed Development, however a Drainage Strategy will still be required to ensure that the Proposed Development will not increase flood risk elsewhere.

Pluvial Flood Risk

4.61. In addition to fluvial and coastal flood risk, NRW also provide surface water flood maps, see **Figure 4.4: Appendix 4A**. This indicates that the small watercourse to the north of Field 1, 3 and 4, as well as the watercourse which dissects Fields 10 and 11 have some minor flood risk issues, however they look to be contained within the watercourse's banks.

4.62. **Figure 4.2** of **Appendix 4A** shows the topographical survey of the Application Site. Where the NRW map demonstrates areas of surface water risk, the topographical survey, as well as aerial maps, were studied to determine if there will indeed be surface water flooding within the Application Site. The watercourses where the surface water issues are located did not appear to have any evidence of out of bank flooding during the site visit. The topographical survey also shows they are well defined and have a gradient which would clearly move water through the watercourses and away from the Proposed Development. There is no electrical infrastructure within 8m of these two watercourses with potential surface water flood risks, only tracks and fencing.

Groundwater Flood Risk

4.63. Groundwater flooding is a "hidden" risk that is often difficult to distinguish from other types of flooding. For example, rising groundwater often forms in low-lying areas which are also susceptible to the accumulation of surface water.

4.64. Local groundwater levels often respond to water levels within nearby watercourses. As there is no fluvial flood risk to the Application Site, groundwater flooding is unlikely to be a significant risk. The PFRA also states:

"It is understood that there is no local information on future groundwater flooding for Monmouthshire. The risk of groundwater flooding is considered to be low, and it is not considered to be a significant issue within the catchment".

4.65. Based on the above, the risk of flooding from groundwater is likely to be low.

Site Access Point

4.66. The access point is off of the unnamed local road to the east of the main development boundary. Although this is an existing access point, it will need to be surfaced and widened for construction vehicles to enter the site. No surface waters will be diverted onto the public road network from the site tracks.

DRAINAGE STRATEGY

Introduction

4.67. All developments in Wales which consist of more than one dwelling house, or where the construction area is 100 square metres or more, requires SuDS to manage surface waters. The SuDS must be designed and built in accordance with Statutory SuDS Standards[21] published by the Welsh Ministers and SuDS Schemes must be approved by the local authority acting in its SuDS Approving Body (SAB) role, before construction work begins.

4.68. The objective of this is to deliver effective, multi-purpose SuDS in new developments that will be maintained and remain effective for the lifetime of the developments they serve.

4.69. Due to the differences in the solar farm and the grid substation elements of the Proposed Development, drainage schemes for these have been designed separately.

Methodology

Catchment Characteristics

4.70. Catchment characteristics were obtained from the Flood Studies Report[22] conducted by the Institute of Hydrology. Catchment sizes were measured using ArcGIS and catchment boundaries were produced based on the site-specific topographical survey.

Greenfield Runoff and Stormwater Storage

4.71. Greenfield runoff rates and stormwater storage requirements have been obtained using the following tools:

- HR Wallingford UK Sustainable Drainage Greenfield Runoff Estimation Tool (using IH124[23] methodology due to the small-scale nature of the catchment).
- Flow – Causeway Drainage design software (using IH124 methodology due to the small-scale nature of the catchment).

[21] Welsh Government, Sustainable Drainage (SuDS) Statutory Guidance, 2019, Available at https://gov.wales/sites/default/files/publications/2019-06/statutory-guidance.pdf

[22] Institute of Hydrology, Flood Studies Report (1975)

[23] Institute of Hydrology (1994). *Flood estimation for small catchments. Report No IH124*, Wallingford.

- The areas of permeable and impermeable surfaces have been estimated and are based upon the Proposed Development layout (**Figure 4 of Volume 2: Planning Application Drawings** for the layout of the Proposed Development).

Greenfield Runoff rates

4.72. The IH24 methodology is used for calculating the Greenfield runoff rates. This is recommended by the Institute of Hydrology for catchments below 200ha.

4.73. The IH124 equation estimates Qbar with the following equation:

$$Qbar - rural = 0.00108\ x\ (0.01\ x\ AREA)0.89\ x\ SAAR1.17\ x\ SPR2.17, m3/s$$

where:

- Qbar-rural is the mean annual flood flow from a rural catchment (approximately 2-3-year return period).
- AREA is the area of the catchment in ha.
- SAAR is the standard average annual rainfall for the period 1961 to 1990, available from the Flood Studies Report
- SPR is Standard Percentage Runoff coefficient for the SOIL category.

Calculating storage estimates

4.74. The storage estimates are calculated using the inputs below:

- Return Period
- Climate Change
- Impermeable Area
- Peak Discharge

4.75. The return period and climate change are combined with the Flood Studies Report (FSR) parameters and storm durations to generate the rainfall used. The result from these calculations is the attenuation storage required for the Application Site as a result of the additional runoff generated by the Proposed Development.

Site and Project Descriptions

4.76. The Proposed Development will have a very limited extent of impermeable ground cover. The area beneath the solar panels will remain grassed and the post development site infiltration rate will not change. Rainwater falling onto each panel will drain freely onto the ground beneath the panel and infiltrate into the ground at the same rate as it does in the site's existing greenfield state as indicated in TIN101[24]. Thus, the total surface area of the photovoltaic array will not be considered an impermeable area in this assessment (only the area taken up by the piles). Similarly, it can be assumed that any rainwater falling onto the permeable access tracks will soak into the ground beneath or adjacent to the tracks at the same rate that it presently does.

4.77. The extent of impermeable area created as a result of the Proposed Development is summarised in Table 4-3.

Table 4 - 3: Extent of less permeable areas created by the Proposed Development

Building	Solar Farm Total Area (m^2)	Grid Substation (m^2)
10 x Transformers (3.74m(L) x 2.95m(W))	110.33	NA
Solar mounting structure piles (14,496 piles)	115.97	NA
58 x CCTV Foundations (0.8m x 0.8m)	37.12	NA
Fence posts (2162 posts)	64.86	NA
Grid Substation Area (Abnormal Shape)	NA	1,625.00
Total Impermeable Area (m^2)	328.28	1,625.00
Total Impermeable Area (m^2)	1,953.28	
Site Area (m^2)	700,300.00	

4.78. In its current greenfield state, the Application Site is considered to be 100% undeveloped. As a result of the Proposed Development, the extent of impermeable hardstanding introduced will be approximately 1,953.28m^2 or 0.28% of the total site area.

[24] Natural England, Technical Information Note TIN101: Solar Parks: Maximising environmental benefits, 2011. Available at https://webarchive.nationalarchives.gov.uk/20150902172007/http://publications.naturalengland.org.uk/publication/32027

4.79. Due to the small size of the transformers and the widespread nature of their locations across the Application Site, it is impractical to connect them into a drainage scheme. Water runoff from these buildings will slowly drain into the underlying geology through infiltration and the impact of this will be **Negligible**. Should surface water accumulate around any of these locations, a simple soakaway can be constructed to allow water soak into the underlying subsoils.

Existing Drainage Arrangements

Existing Runoff Rates

4.80. The existing runoff rates and hydrological characteristics of the Proposed Development are detailed in **Table 4-4** below (there are no hardstanding areas on the site at present).

Table 4 - 4: Pre-Development Greenfield runoff rates.

Site Make Up	Solar Farm Green Field	Grid Green Field
Greenfield Method	IH124	IH124
Positively Drained Area (ha)	0.033	0.163
SAAR (mm)	981	981
Soil Index	2	2
Standard Percentage Runoff	0.3	0.3
Region	9	9
	Runoff rate (l/s)	**Runoff rate (l/s)**
QBar	0.1	0.4
1 year	0.1	0.4
1 in 30 year	0.2	0.9
1 in 100 year	0.2	1.1

4.81. The limiting discharge should be calculated as the flow rates from the pre-developed site, as detailed in **Table 4-4**.

Post Development Runoff Rate

4.82. The surface water runoff rate resulting from the Proposed Development has been based on the areas of hardstanding introduced, which will have a lower permeability than the existing greenfield composition.

4.83. Surface water runoff was derived using the Modified Rational Method as outlined within the methodology.

4.84. Using this approach, the runoff rate for the 1-in-100-year, 360-minute storm event, inclusive of the 20% climate change allowance would be a combined **48m^3**, across the three site areas, if left unmanaged.

Proposed Drainage Arrangements

4.85. The SuDS Manual[25] is the current best practice guidance on the use of SuDS. It promotes the use of a hierarchical approach to managing runoff. This approach is outlined below:

- Prevention - Preventing runoff by reducing impermeable areas.
- Source Control - Effective control of runoff at or very near its source.
- Site Control- Planned management of water in a local area or site.
- Regional Control - Designing a system that can efficiently manage the runoff from a site, or several sites.

4.86. The use of SuDS is generally accepted to have greater benefits than conventional drainage systems and these include[26]:

- Managing runoff volumes and flow rates from hard surfaces, reducing the impact of urbanisation on flooding;
- Providing opportunities for using runoff where it falls;
- Protecting or enhancing water quality (reducing pollution from runoff);
- Protecting natural flow regimes in watercourses;

25 CIRIA (2015). Report C753, The SuDS Manual

26 Susdrain. Sustainable drainage. Accessed http://www.susdrain.org/delivering-suds/using-suds/background/sustainable-drainage.html

- SuDs are sympathetic to the environment and the needs of the local community;
- Providing an attractive habitat for wildlife in urban watercourses;
- Providing opportunities for evapotranspiration from vegetation and surface water; and
- Encouraging natural groundwater/aquifer recharge (where appropriate).

4.87. The surface water drainage strategy for the Proposed Development seeks to provide a sustainable and integrated surface water management scheme for the whole Application Site and aims to ensure no increase in downstream flood risk by managing discharges from the Proposed Development to the local water environment in a controlled manner.

4.88. To comply with current policies, guidance and best practice, the volume and quality of surface water runoff discharged off-site from the Proposed Development at this Application Site will need to be controlled using SuDS.

4.89. In compliance with the above, the drainage strategy has been developed to meet the following key principles;

- Mimic existing (greenfield) drainage arrangements as far as possible;
- Avoid increases in the greenfield rate, volume and frequency of offsite discharge;
- Avoid significant deterioration in water quality of discharges and no detrimental impact in downstream water quality;
- Achieve the above criteria for all storms up to and including the 100-year event; and,
- Incorporate an allowance for climate change (20%).

Indicative Surface Water Storage Requirements

4.90. Indicative storm water storage volumes have been estimated using Causeway's Drainage Design Flow software. The storage calculations include up to the critical storm 100-year return period event (including a 20% allowance for climate change) and the design limits discharge rates back to greenfield runoff rates (QBar). The results are enclosed in **Appendix 4B and 4C.** These are estimated from the new surfaces added to the Proposed Development.

- Attenuation storage limits the rate of surface runoff discharge from the Proposed Development to match the pre-development greenfield runoff rates (QBar); and,
- All storage calculations have been given a climate change allowance factor of 20% that has been added to the rain depths.

Table 4 - 5: Storage Estimates

Storage Estimates		
	Solar Farm	Grid Substation
Return Period (years)	100 years	100 years
Climate Change (%)	20	20
Impermeable Area (ha)	0.033	0.163
Peak Discharge (l/s)	0.1	0.4
Total storage Requirement (m^3)	31.0	131.0

Proposed Drainage Strategy (Solar Farm)

4.91. It is proposed to construct six soakaway channels/ filter drains within the Application Site. The location of the channels has been chosen to intercept flows before they enter the existing drainage system surrounding the site, see Figure 4.5 in Appendix 4A.

4.92. The proposed soakaways will have an overall combined length of approximately 1,243m, with a base width of 0.5m, a 0.5m design depth and a 0.15m freeboard. They will be filled with crushed rock with a void ratio of 20%.

4.93. It will provide a total storage volume of approximately 62.2m^3. This is greater than the volume of additional runoff generated as a result of the impermeable buildings (31.0m^3). It is therefore considered that this adequately mitigates the increase in flow rates as a result of the minor increase in impermeable area and provides improvement.

4.94. The soakaway channels/ filter drains will be implemented during the construction phase of the Proposed Solar Farm and planted with vegetation to protect against soil erosion. They will be maintained throughout the lifespan of the Proposed Development, generally in accordance with the recommendations in the appropriate guidance.

Proposed Drainage Strategy (Grid Substation)

4.95. It is proposed that surface run-off will be collected and conveyed by the provision of filter drains to a detention basin as shown in Figure 4.6: Appendix 4A. A notional freeboard level of 150mm shall be incorporated into the detention basin for the 1 in 100-year storm event with the final design of the pond being submitted for SAB approval prior to the construction period. Calculations are included in Appendix 4C and the design volume of the detention basin will be a minimum of 131m^3.

4.96. As stated previously, the grid substation area is underlain by clays which exclude infiltration techniques for surface water disposal. QBAR discharge rate restriction as noted in Table 4-5 satisfies the requirements of the SuDS Manual '*Designing for Long Term Storage'*. Final discharge is restricted at the pond by the provision of a Hydro-Brake® vortex flow control device, or a device of similar quality.

4.97. Due to very infrequent site attendance that is required, the pollution risk is deemed negligible. On-plot surface water treatment is provided in the form of filter drains wrapped to intercept the conveyance of any silts within the drainage system. Further downstream, water quality polishing is provided within the detention basin prior to discharge from site.

4.98. The discharge point will be into the existing site field drainage to the north west of the detention basin.

4.99. Additional drainage measures to be implemented on-site include the following:

- Solar Panels: current grass cover is to be retained or reinstated adjacent to and under panels in order to maximise bio-retention;
- Access Tracks: access tracks are to be unpaved and constructed from local stone. Temporary swales or similar shall be utilised to collect runoff from access tracks with discharge to ground through percolation areas. Where swales are utilised, frequent check dams formed from gravels and other excavated material should be undertaken; and
- Transformer Stations: the scale of these types of structures is unlikely to warrant a formalised drainage system. Runoff from this infrastructure and any associated hard standing should be directed to a percolation area for discharge to ground. Should surface water accumulate around any of these locations then a simple soakaway can be constructed to allow water soak into the underlying subsoils.

Construction Phase

4.100. Due to the addition of the temporary construction compound during the construction phase, additional drainage measures will be implemented to help attenuate the increase in surface water flows. Runoff from these areas is anticipated to have high silt loading due to mobilised soils from excavated surfaces, fines from track aggregate and sludge due to traffic.

4.101. Hardstanding runoff will be directed to a swale on the compound's lowest boundary. This drainage scheme will be removed at the end of the construction stage and the area reinstated.

Designing for Exceedance Events

4.102. Overland flow routes will not be altered by the construction of the Proposed Development as it is not proposed to significantly vary ground levels. The outline drainage has been designed so that flooding will not occur for up to and including the 1-in-100-year storm event (including 20% climate change consideration).

4.103. Should an exceedance of this 1 in 100-year critical storm event occur, surface water will flow the same way as at present, into the surrounding field drains. There are no sensitive receptors between the Application Site and the field drains.

Long Term Maintenance of SuDS

4.104. The long-term management and maintenance of the proposed SuDS will be the responsibility of the site owner and/or operators. These responsibilities include:

- Periodic cutting or grazing of vegetation;
- Observation of infiltration performance;
- Litter and debris removal;
- If poor infiltration is observed then any accumulated silt/litter will be removed and aeration of the soil will be undertaken to improve permeability; and
- Maintain the structural integrity of the infiltration trenches/ attenuation structure.

4.105. The timing of the provision of the swales is important and dependent upon the existing condition of the site immediately prior to construction commencing, and weather conditions prior to, and during, construction, as any existing vegetation needs to be retained as far as possible during the construction period.

SAB Approval

4.106. A SAB application will be made to Monmouthshire County Council following planning permission being granted and will be on the basis of the details of the SuDS measures set out above.

- A pre application SAB meeting took place on the 23rd July 2020 where a number of points relating to the drainage design were discussed. The main points were:
- Infiltration testing required at the substation drainage location
- Soakaways / Swales to be located at the downhill edge of fields

- Localised soakaways to be located at the transformer locations
- Access tracks to include permeable membrane and crushed type one rock to allow rainwater to percolate through
- Final preapplication meeting to take place once the drainage design is complete

Potential for Soil Erosion

4.107. The key to avoiding increased runoff and the transport of soil into watercourses is to maintain soil permeability and vegetative cover. Permeable land surfaces underneath and between panels should be able to absorb rainfall as long as they are not compacted and there is some vegetation to bind the soil surface.

4.108. Soil compaction will be limited during construction and operation of the solar farm. During construction, only light machinery will be required to install the solar arrays. Any Heavy Goods Vehicles (HGVs) delivering components will be restricted to site access tracks and the temporary construction compounds.

4.109. To alleviate the effects of any limited compaction during the construction process any affected areas will be harrowed prior to being reseeded.

4.110. The risks of runoff and soil erosion are lowest on land with a gradual gradient with cohesive soils and are highest on dry, sandy and steeply sloping soil surfaces. Furthermore, the slope aspect of the land can also have an effect on runoff rates and soil erosion. The aspect of static solar panels in Wales will mostly always be south-facing and, therefore, north or south facing slopes will result in runoff flowing in a parallel direction to that of the runoff from the panels; thereby remaining relatively diffuse and unlikely to result in concentrated flows that could cause soil erosion, apart from where very steep slopes occur.

4.111. East or west facing slopes will result in runoff flowing in a perpendicular direction to that of runoff from the panels; this will result in runoff becoming concentrated along the drip-line of each row, which could lead to increased soil erosion.

4.112. With regard to the Proposed Development, there is a gentle gradient across most of the fields with steeper gradients towards the high point in Field 5. The orientation of the solar panels could concentrate surface water flow in some areas of the Application Site and increase the risk of soil erosion. However, due to the low gradient across these fields, the likelihood of increased overland flow or soil erosion occurring is considered low. The addition of the filter drains / soakaway trenches on the downstream boundary of the fields with the steeper gradients will reduce the risk of soil erosion on these fields and reduce any risk of water quality issues on any downstream watercourses or agricultural land.

SUMMARY & CONCLUSIONS

4.113. The FCA and DS requirements are set out by the PPW and TAN15 and guidance.

4.114. The Guidance aims to avoid inappropriate development in flood zones and instead direct it to areas of low risk by adopting a sequential approach.

4.115. According to the DAM, the Application Site is wholly situated within Flood Zone A, except for a small area within Field 4, which is Flood Zone B. However, this area has been avoided of development and therefore the Proposed Development is wholly within Flood Zone A. Therefore, in accordance with TAN15, the Application Site is situated in an area that that is at little or no risk of fluvial or tidal/coastal flooding. Consequently, a justification test is not required for this Proposed Development, however a Drainage Strategy will still be required to ensure that the Proposed Development will not increase flooding elsewhere.

4.116. In addition to fluvial and coastal flood risk, the NRW also provide surface water flood maps. This indicates that the small watercourse to the north of Field 1, 3 and 4, as well as the watercourse which dissects Fields 10 and 11 have some minor flood risk issues, however they look to be contained within the watercourse's banks.

4.117. Where the NRW map demonstrates areas of surface water risk, the topographical survey, as well as aerial maps, were studied to determine if there will indeed be surface water flooding within the Application Site. The watercourses where the surface water issues are located did not appear to have any evidence of out of bank flooding during the site visit. The topographical survey also shows they are well defined and have a gradient which would clearly move water through the watercourses and away from the Proposed Development. There is no electrical infrastructure within 8m of these two watercourses with potential surface water flood risks, only tracks and fencing.

4.118. It has been demonstrated that the Proposed Developments impact on surface water runoff is minimal due to the small amount of impermeable infrastructure (0.28% of the overall Application Site Area) proposed for the Application Site. However, drainage in the form of SuDS has been proposed so the post developed site discharges surface water at the greenfield run off rate (QBar). Due to large area of the Grid Substation, and the dispersed nature of the impermeable development of the rest of the Proposed Development, drainage schemes for these have been designed separately.

4.119. Soil permeability testing was undertaken to the north of where the grid substation is being located within Field 3 of the Application Site. The soil description at this location is described as '*Reddish brown sandy, gravelly CLAY. Sand is fine - medium. Gravel is medium - coarse, angular of mixed lithology*'. The soils encountered beneath the site were found to be predominantly CLAY, which contradicts the Soilscapes maps in this location. The soakage rates obtained during the investigation were found to be practically impermeable. Given the data from the test, it is considered that soakaways are not suitable at the grid substation location.

Further testing will be undertaken at the soakaway channels/ filter drains locations prior to the construction period to determine whether they locations are suitable for infiltration.

Proposed Drainage Strategy (Solar Farm)

4.120. It is proposed to construct six soakaway channels/ filter drains within the Application Site. The location of the channels has been chosen to intercept flows before they enter the existing drainage system surrounding the site.

4.121. The proposed soakaways will have an overall combined length of approximately 1,243m, with a base width of 0.5m, a 0.5m design depth and a 0.15m freeboard. They will be filled with crushed rock with a void ratio of 20%.

4.122. It will provide a total storage volume of approximately 62.2m^3. This is greater than the volume of additional runoff generated as a result of the impermeable buildings (31.0m^3). It is therefore considered that this adequately mitigates the increase in flow rates as a result of the minor increase in impermeable area and provides improvement.

Proposed Drainage Strategy (Grid Substation)

4.123. It is proposed that surface run-off will be collected and conveyed by the provision of filter drains to a detention basin. A notional freeboard level of 150mm shall be incorporated into the detention basin for the 1 in 100 year storm event with the final design of the pond being submitted for SAB approval prior to the construction period. The design volume of the detention basin will be a minimum of 131m^3.

4.124. As stated previously, the grid substation area is underlain by clays which exclude infiltration techniques for surface water disposal. QBAR discharge rate restriction satisfies the requirements of the SuDS Manual '*Designing for Long Term Storage'*. Final discharge is restricted at the pond by the provision of a Hydro-Brake® vortex flow control device, or a device of similar quality.

4.125. The discharge point will be into the existing site field drainage to the north west of the detention basin.

4.126. Additional drainage measures to be implemented on-site include the following:

- Solar Panels: current grass cover is to be retained or reinstated adjacent to and under panels in order to maximise bio-retention;
- Access Tracks: access tracks are to be unpaved and constructed from local stone. Temporary swales or similar shall be utilised to collect runoff from access tracks with discharge to ground through percolation areas. Where swales are utilised, frequent

check dams formed from gravels and other excavated material should be undertaken; and

- **Transformer Stations:** the scale of these types of structures is unlikely to warrant a formalised drainage system. Runoff from this infrastructure and any associated hard standing should be directed to a percolation area for discharge to ground. Should surface water accumulate around any of these locations then a simple soakaway can be constructed to allow water soak into the underlying subsoils.

4.127. The FCA and DS has therefore demonstrated that the Proposed Development will **not increase flood risk** away from the Application Site during the construction, operation and decommissioning phases. The Proposed Development is therefore considered to be acceptable in planning policy terms.

APPENDICES

Appendix 4A Figures:

- Figure 4.1: Watercourses Map;
- Figure 4.2: Topographical Survey
- Figure 4.3: Development Advice Map
- Figure 4.4: Flood Risk Map
- Figure 4.5: Outline SuDS Design (Solar Farm)
- Figure 4.6: Outline SuDS Design (Grid)

Appendix 4B: Flow Output (Solar Farm)

Appendix 4C: Flow Output (Grid Substation)

Appendix 4D: BRE 365 Test and Report

Appendix 4A: Figures

Penpergwm Solar Farm
Watercourse Map
Figure 4.1

Key

- Development Boundary
- Panel Boundary
- Small Watercourse
- Main Watercourse Network

Ffrwd Brook

Afon Wysg

Afon Wysg

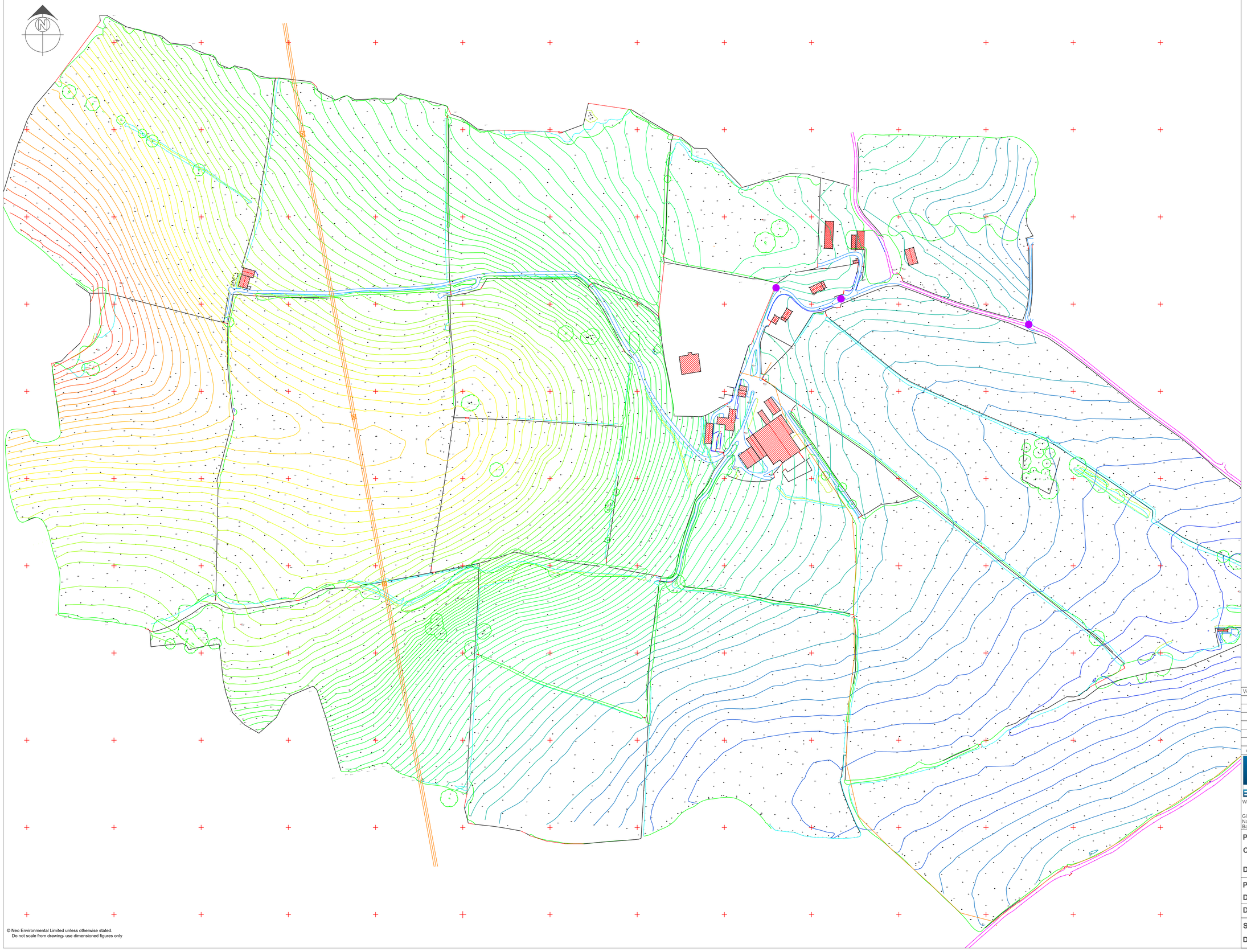
Maxar, Microsoft

0 0.25 0.5 1 Kilometers

Neo Office Address:
Wright Business Centre, 1 Lonmay Road, Glasgow, G33 4EL

Date: 06/05/2021
Drawn By: Michael McGhee
Scale (A3): 1:12,000
Drawing No: NEO00668/088I/A

neo ENVIRONMENTAL



Drawn By: Jamie McGhee
Address: Wright Business Centre
1 Lonmay Road
Glasgow
G33 4EL

Ver.	Date	Comments
A	10/05/2021	

ENVIRONMENTAL
Warrington Office: T:01925 661 716 E: info@neo-environmental.co.uk

Glasgow Office: T: 0141 773 6262 E: info@neo-environmental.co.uk
Naas Office: T:00353 (0)45 844250 E: info@neo-environmental.ie
Ballymena Office: T:0282 565 0413 E: info@neo-environmental.co.uk

Project:	Penpergwym Solar Farm
Client:	Renewable Connection
Drawing:	Topographical Survey
Project No.:	NEO00668
Drawing No. :	NEO00668_089I_A Figure 4.2
Drawn: JM	**Checked:** MM **Approved:** PN
Scale:	1:2,000 @ A1 **Revision:**
Date:	10 May 2021 A

Cyfoeth Naturiol Cymru
Natural Resources Wales

Figure 4.3. DAM

Allwedd / Map Key

- Zone C1
- Zone C2
- Zone B
- Zone A

Graddfa / Scale at A3 1: 11,716

Dyddiad / Date
28/04/2021

0.6 0 0.30 0.6

British_National_Grid Kilometers

Cyfoeth Naturiol Cymru
Natural Resources Wales

Figure 4.4 Flood Risk Map

Allwedd / Map Key

- Flood Storage Areas
- Risk Level Under Review
- Flood Risk from Surface Water & Small Watercourses - Extent
  - High
  - Medium
  - Low
- Recorded Flood Extents
- Flood Risk from Reservoirs

Graddfa / Scale at A3 1: 29,290

Dyddiad / Date
05/05/2021

1.5 0 0.74 1.5
British_National_Grid Kilometers

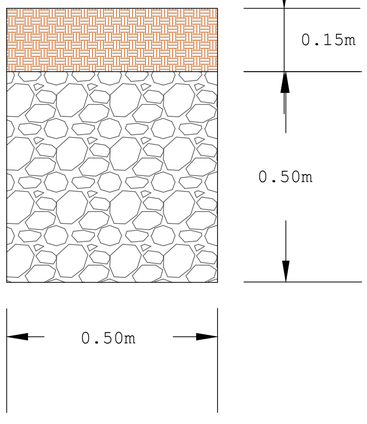
Filter Drains

Filter Drains

Key

- Development Boundary
- Solar PV Array
- Access Track
- Construction Compound
- Transformer
- Substation
- Security Fencing
- Existing Vegetation
- Filter Drains

Filter Drain Detail - NTS



Ver.	Date	Comments
A	06/05/2021	

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Naas Office: T:00353 (0)45 844250 E: info@neo-environmental.ie
Ballymena Office: T:0282 565 0413 E: info@neo-environmental.co.uk

Project:	Penpergwm Solar Farm
Client:	Renewable Connections
Drawing:	Outline SuDs Design
Project No.:	NEO00668
Drawing No. :	NEO00668_087I_A Figure 4.5
Drawn: JM	**Checked:** MM **Approved:** PN
Scale:	1:2,000 @ A1 **Revision:**
Date:	06 May 2021 A

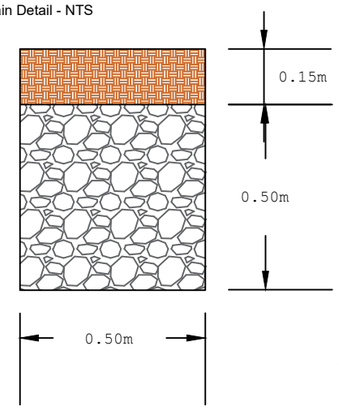
Discharge Point

Flow control device set at 0.4l/s

Key

- Development Boundary
- Solar PV Array
- Access Track
- Substation
- Fencing
- CCTV
- Detention Basin (Design Volume = 131m3
- Filter Drains

Filter Drain Detail - NTS



Drawn By: Jamie McGhee
Address: Wright Business Centre
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Ver.	Date	Comments
A	06/05/2021	

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Project: Penpergwm Solar Farm
Client: Renewable Connections

Drawing: Outline SuDs Design (Grid)

Project No.: NEO00668
Drawing No.: NEO00668_086I_A Figure 4.6

Drawn: JM **Checked:** MM **Approved:** PN

Scale: 1:500 @ A3 **Revision:** A
Date: 06 May 2021

Appendix 4B: Flow Output (Solar Farm)

Design Settings

Rainfall Methodology	FSR	Maximum Time of Concentration (mins)	30.00
Return Period (years)	30	Maximum Rainfall (mm/hr)	50.0
Additional Flow (%)	0	Minimum Velocity (m/s)	1.00
FSR Region	England and Wales	Connection Type	Level Soffits
M5-60 (mm)	20.000	Minimum Backdrop Height (m)	0.200
Ratio-R	0.300	Preferred Cover Depth (m)	1.200
CV	0.750	Include Intermediate Ground	✓
Time of Entry (mins)	5.00	Enforce best practice design rules	✓

Simulation Settings

Rainfall Methodology	FSR	Drain Down Time (mins)	240
FSR Region	England and Wales	Additional Storage (m³/ha)	20.0
M5-60 (mm)	20.000	Check Discharge Rate(s)	✓
Ratio-R	0.300	1 year (l/s)	0.1
Summer CV	0.750	30 year (l/s)	0.2
Winter CV	0.840	100 year (l/s)	0.2
Analysis Speed	Normal	Check Discharge Volume	✓
Skip Steady State	x	100 year 360 minute (m³)	8

Storm Durations

15	30	60	120	180	240	360	480	600	720	960	1440

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
1	0	0	0
30	0	0	0
100	20	0	0

Pre-development Discharge Rate

Site Makeup	Greenfield	Growth Factor 30 year	1.80
Greenfield Method	IH124	Growth Factor 100 year	2.18
Positively Drained Area (ha)	0.033	Betterment (%)	0
SAAR (mm)	981	QBar	0.1
Soil Index	2	Q 1 year (l/s)	0.1
SPR	0.30	Q 30 year (l/s)	0.2
Region	9	Q 100 year (l/s)	0.2
Growth Factor 1 year	0.88		

Pre-development Discharge Volume

Site Makeup	Greenfield	Return Period (years)	100
Greenfield Method	FSR/FEH	Climate Change (%)	0
Positively Drained Area (ha)	0.033	Storm Duration (mins)	360
Soil Index	2	Betterment (%)	0
SPR	0.30	PR	0.348
CWI	124.953	Runoff Volume (m³)	8

Appendix 4C: Flow Output (Grid)

Design Settings

Rainfall Methodology	FSR	Maximum Time of Concentration (mins)	30.00
Return Period (years)	30	Maximum Rainfall (mm/hr)	50.0
Additional Flow (%)	0	Minimum Velocity (m/s)	1.00
FSR Region	England and Wales	Connection Type	Level Soffits
M5-60 (mm)	20.000	Minimum Backdrop Height (m)	0.200
Ratio-R	0.300	Preferred Cover Depth (m)	1.200
CV	0.750	Include Intermediate Ground	✓
Time of Entry (mins)	5.00	Enforce best practice design rules	✓

Simulation Settings

Rainfall Methodology	FSR	Drain Down Time (mins)	240
FSR Region	England and Wales	Additional Storage (m³/ha)	20.0
M5-60 (mm)	20.000	Check Discharge Rate(s)	✓
Ratio-R	0.300	1 year (l/s)	0.4
Summer CV	0.750	30 year (l/s)	0.8
Winter CV	0.840	100 year (l/s)	1.0
Analysis Speed	Normal	Check Discharge Volume	✓
Skip Steady State	x	100 year 360 minute (m³)	40

Storm Durations

15	30	60	120	180	240	360	480	600	720	960	1440

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
1	0	0	0
30	0	0	0
100	20	0	0

Pre-development Discharge Rate

Site Makeup	Greenfield	Growth Factor 30 year	1.95
Greenfield Method	IH124	Growth Factor 100 year	2.48
Positively Drained Area (ha)	0.163	Betterment (%)	0
SAAR (mm)	981	QBar	0.4
Soil Index	2	Q 1 year (l/s)	0.4
SPR	0.30	Q 30 year (l/s)	0.9
Region	9	Q 100 year (l/s)	1.1
Growth Factor 1 year	0.85		

Pre-development Discharge Volume

Site Makeup	Greenfield	Return Period (years)	100
Greenfield Method	FSR/FEH	Climate Change (%)	0
Positively Drained Area (ha)	0.163	Storm Duration (mins)	360
Soil Index	2	Betterment (%)	0
SPR	0.30	PR	0.348
CWI	124.953	Runoff Volume (m³)	40

Appendix 4D: BRE 365 Test and Report

Our Ref: YEX1523

19th April 2021

For the attention of Neo Environmental Ltd,

Ref: Land at Penpergym, Abergavenny, South Wales

We thank you for your request to undertake permeability testing at the above mentioned site and take pleasure in enclosing the results of this work. The investigation was undertaken on the 13th April 2021 in accordance with your instruction to proceed. This letter describes the work undertaken, presents the data obtained and discusses the results of the tests.

Geology

An examination of the available British Geological Survey data of the area for the site has been examined and indicates that the site has superficial drift deposits composed of the Glaciofluvial Sheet Deposits, Devensian (sand and gravel), and bedrock deposits recorded as the Raglan Mudstone Formation (siltstone and mudstone, interbedded).

Fieldworks

The programme of this investigation included the excavation of three trial pits. The locations of the soakaway tests were selected by the client.

During this work, the soils encountered were logged in general accordance with BS 5930: 1990, as amended in 2007, and full descriptions are given on the borehole records, which are also appended to this letter.

Soakaway Tests

During the soakaway tests the water failed to achieve a fall from 75% to 25% of the effective depth of the storage volume in all three trial pits. The results obtained from the soakaway tests are summarised below:

Table 1: *Soakaway Test Results*

WS	Soakage Area Dimensions (m)	Depth (m)	Soil Description (Base of TP)	Infiltration Rate (m/sec)	Drainage Characteristics
TP01 test1	1.40 x 0.60	1.50	Reddish brown sandy, gravelly CLAY. Sand is fine - medium. Gravel is medium - coarse, angular of mixed lithology.	N/A	Practically Impermeable
TP02 test1	1.50 x 0.60	1.50	Reddish brown sandy, gravelly CLAY. Sand is fine - medium. Gravel is medium - coarse, angular of mixed lithology.	N/A	Practically Impermeable

TP03 test1	1.60 x 0.60	1.50	Reddish brown sandy, gravelly CLAY. Sand is fine - medium. Gravel is medium - coarse, angular of mixed lithology.	N/A	Practically Impermeable

Discussion

The soils encountered beneath the site were found to be predominantly CLAY. The soakage rates obtained during the investigation were found to be practically impermeable. Given the data from the test, it is considered that soakaways are not suitable for this site.

References

Building Research Establishment (BRE) Digest 365, *Soakaway Design*, September 1991.

British Standards Institution (1999) BS5930: *Code of practice for site investigations*, B.S.I., London.

British Standards Institution (2007), Amendment No 1, BS5930: *Code of practice for site investigations*, B.S.I., London.

We trust that this information is of interest and should you have any other requirements do not hesitate to contact us.

For and on behalf of

*Your*Environment

Yours Faithfully,

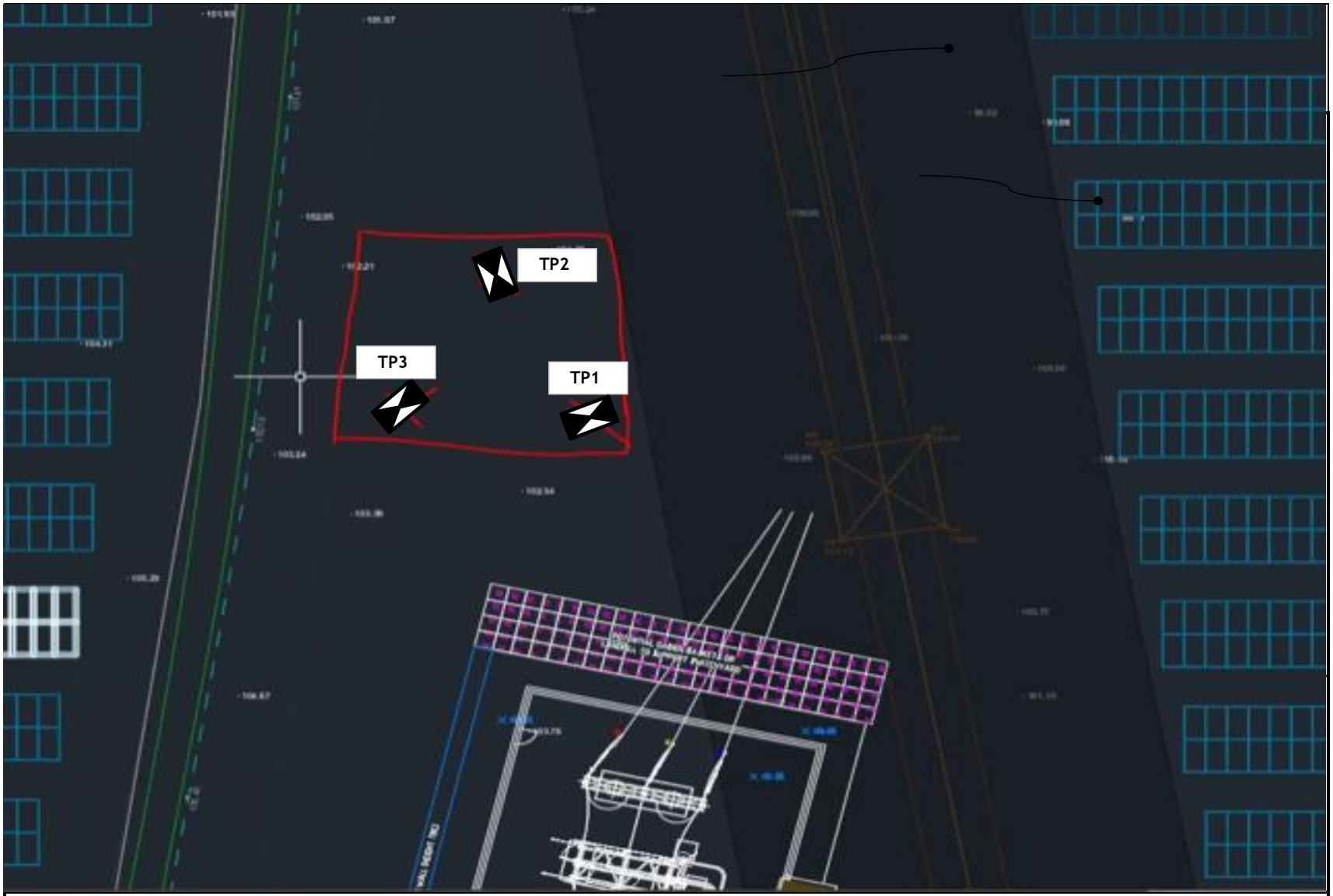
Nick Hammond

Geo-Environmental Engineer

Enc.

Appendix A: Site Investigation Plan
Appendix B: Trial Pit Logs
Appendix C: Soakaway Test Results

APPENDIX A: Site Investigation Plan



Your Environment

Ground Investigation Location Plan - Not to Scale

YourEnvironment
Chilgrove Business Centre, Chilgrove, Nr Chichester, PO18 9HU
Tel: 01243 787150
Email: info@yourenvironment.org

Site Name:	Client:	Date:	Job No:
Land at Penpergym	Neo Environmental Ltd	Apr-21	YEX1523

APPENDIX B: Trial Pit Logs

Your Environment
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Log of Boring TP1
Sheet 1 of 1

YE Engineer N. Hammond

Location	Land at Penpergym, Abergavenny, South Wales
Date	April 13, 2021
Project Reference	YEX1523

Water level data
Completion: Depth NA m
Elevation NA m
24 hour: Depth ____ m
Elevation ____ m

Width 0.6 m
Length 1.4 m
Depth 1.5 m

Method (Trial pit, window etc) Trial Pit - Machine Excavation

Stratum depth (m) From	Stratum depth (m) To	Sample Depth From (m)	Sample Depth To (m)	Sample Type	GW	Install Details	LITHOLOGY
0.00	0.30					NONE	Reddish brown clayey SAND. Sand is fine - medium.
0.30	1.50						Reddish brown sandy, gravelly CLAY. Sand is fine - medium. Gravel is medium - coarse, angular of mixed lithology.
							End of TP1

Remarks: .

Your Environment

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Log of Boring TP2
Sheet 1 of 1

YE Engineer N. Hammond

Location	Land at Penpergym, Abergavenny, South Wales
Date	April 13, 2021
Project Reference	YEX1523

Water level data

Completion: Depth NA m
Elevation NA m

24 hour: Depth ____ m
Elevation ____ m

Width 0.6 m
Length 1.5 m
Depth 1.5 m

Method (Trial pit, window etc) Trial Pit - Machine Excavation

Stratum depth (m) From	Stratum depth (m) To	Sample Depth From (m)	Sample Depth To (m)	Sample Type	GW	Install Details	LITHOLOGY
0.00	0.20					NONE	Reddish brown clayey SAND. Sand is fine - medium.
0.20	1.50						Reddish brown sandy, gravelly CLAY. Sand is fine - medium. Gravel is medium - coarse, angular of mixed lithology.
							End of TP2

Remarks: .

Your Environment

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Log of Boring TP3
Sheet 1 of 1

YE Engineer N. Hammond

Location	Land at Penpergym, Abergavenny, South Wales
Date	April 13, 2021
Project Reference	YEX1523

Water level data

Completion: Depth NA m
Elevation NA m

24 hour: Depth ____ m
Elevation ____ m

Width 0.6 m
Length 1.6 m
Depth 1.5 m

Method (Trial pit, window etc) Trial Pit - Machine Excavation

Stratum depth (m) From	Stratum depth (m) To	Sample Depth From (m)	Sample Depth To (m)	Sample Type	GW	Install Details	LITHOLOGY
0.00	0.30					NONE	Reddish brown clayey SAND. Sand is fine - medium.
0.30	1.50						Reddish brown sandy, gravelly CLAY. Sand is fine - medium. Gravel is medium - coarse, angular of mixed lithology.
							End of TP3

Remarks: .

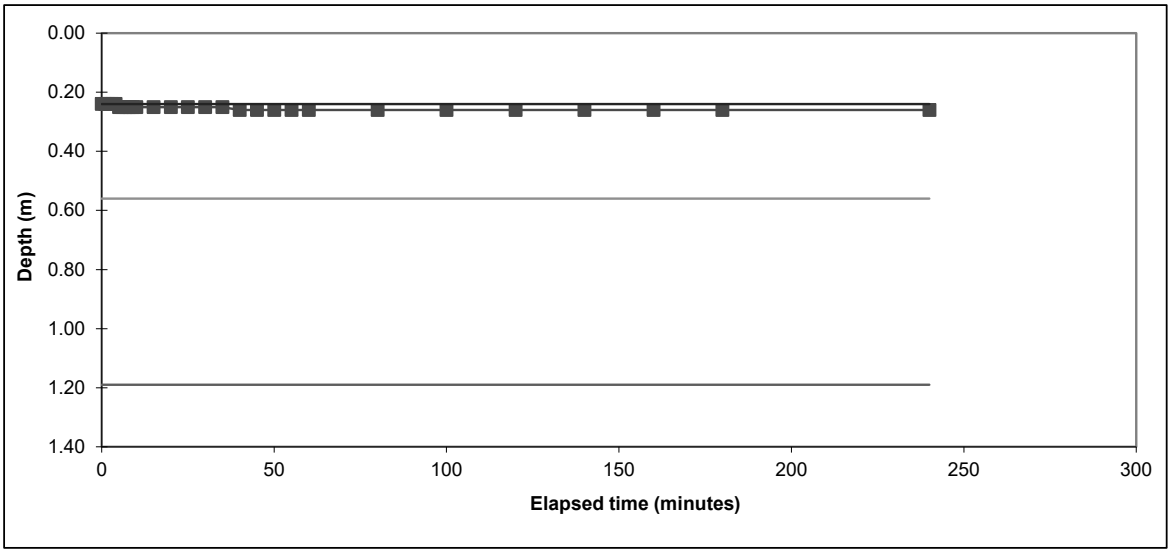
APPENDIX C: Soakaway Test Results

Your Environment

Soakaway Test

Trial Pit No:	TP1	Test No:	1	Date:	13/04/2021
Length (m):	1.400		Datum Height:	0.00	m agl
Width (m):	0.60		Granular infill:	None	
Depth (m):	1.50		Porosity of infill:	1	(assumed)

Elapsed time (minutes)	Water Depth (m below datum)	Elapsed time (minutes)	Water Depth (m below datum)
0	0.240	30	0.250
1	0.240	35	0.250
2	0.240	40	0.260
3	0.240	45	0.260
4	0.240	50	0.260
5	0.250	55	0.260
6	0.250	60	0.260
7	0.250	80	0.260
8	0.250	100	0.260
9	0.250	120	0.260
10	0.250	140	0.260
15	0.250	160	0.260
20	0.250	180	0.260
25	0.250	240	0.260



Start water depth for analysis (mbgl)	0.24		
75% effective depth (mbgl):	0.56	Elapsed time (mins):	#N/A
50% effective depth (mbgl):	0.87		
25% effective depth (mbgl):	1.19	Elapsed time (mins):	#N/A
Base of soakage zone (mbgl):	1.50		
Volume outflow between 75% and 25% effective depth (m^3):			
Mean surface area of outflow (m^2):		3.36	
(side area at 50% effective depth + base area)			
Time for outflow between 75% and 25% effective depth (mins):			

Soil infiltration rate (m/s):	**Test incomplete as 25% effective depth not achieved. Unable to reliably determine soil infiltration rate.**

Remarks Results processed following BRE 365 (2007).

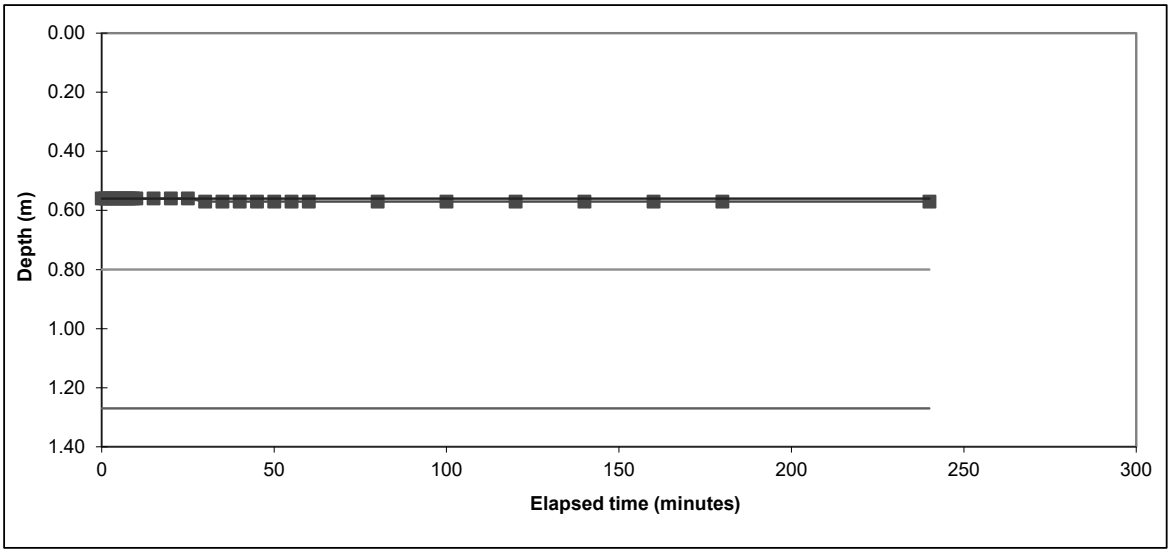
Client:	Neo Environmental Ltd	**TP1**
Site:	Land at Pempergym	

Your Environment

Soakaway Test

Trial Pit No:	TP2	Test No:	1	Date:	13/04/2021
Length (m):	1.500		Datum Height:	0.00	m agl
Width (m):	0.60		Granular infill:	None	
Depth (m):	1.50		Porosity of infill:	1	(assumed)

Elapsed time (minutes)	Water Depth (m below datum)	Elapsed time (minutes)	Water Depth (m below datum)
0	0.560	30	0.570
1	0.560	35	0.570
2	0.560	40	0.570
3	0.560	45	0.570
4	0.560	50	0.570
5	0.560	55	0.570
6	0.560	60	0.570
7	0.560	80	0.570
8	0.560	100	0.570
9	0.560	120	0.570
10	0.560	140	0.570
15	0.560	160	0.570
20	0.560	180	0.570
25	0.560	240	0.570



Start water depth for analysis (mbgl)	0.56		
75% effective depth (mbgl):	0.80	Elapsed time (mins):	#N/A
50% effective depth (mbgl):	1.03		
25% effective depth (mbgl):	1.27	Elapsed time (mins):	#N/A
Base of soakage zone (mbgl):	1.50		
Volume outflow between 75% and 25% effective depth (m^3):			
Mean surface area of outflow (m^2):		2.87	
(side area at 50% effective depth + base area)			
Time for outflow between 75% and 25% effective depth (mins):			

Soil infiltration rate (m/s):	**Test incomplete as 25% effective depth not achieved. Unable to reliably determine soil infiltration rate.**

Remarks Results processed following BRE 365 (2007).

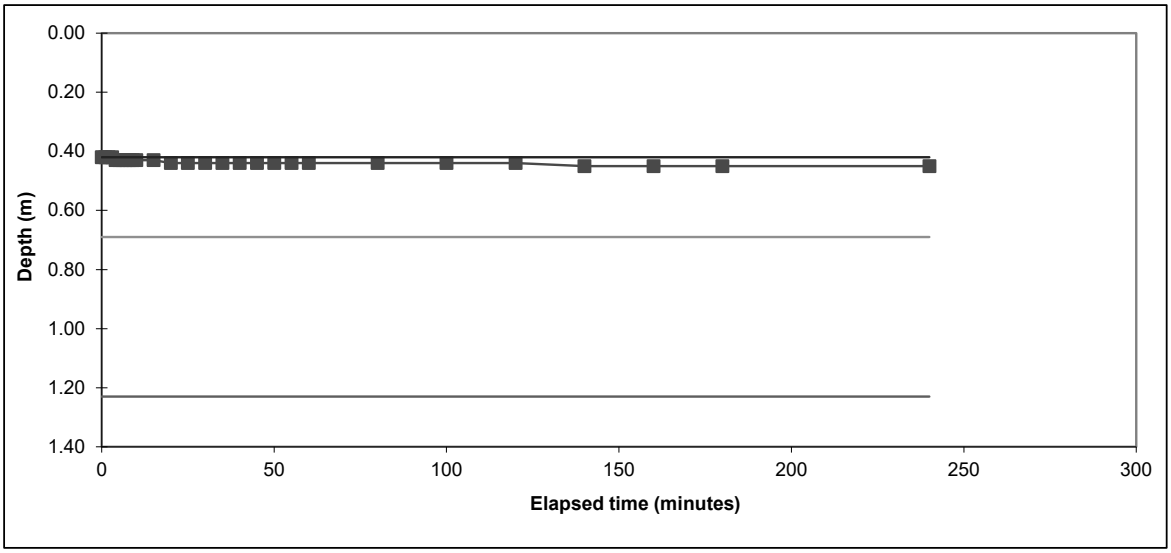
Client:	Neo Environmental Ltd	**TP2**
Site:	Land at Pempergym	

Your Environment

Soakaway Test

Trial Pit No:	TP3	Test No:	1	Date:	13/04/2021
Length (m):	1.600		Datum Height:	0.00	m agl
Width (m):	0.60		Granular infill:	None	
Depth (m):	1.50		Porosity of infill:	1	(assumed)

Elapsed time (minutes)	Water Depth (m below datum)	Elapsed time (minutes)	Water Depth (m below datum)
0	0.420	30	0.440
1	0.420	35	0.440
2	0.420	40	0.440
3	0.420	45	0.440
4	0.430	50	0.440
5	0.430	55	0.440
6	0.430	60	0.440
7	0.430	80	0.440
8	0.430	100	0.440
9	0.430	120	0.440
10	0.430	140	0.450
15	0.430	160	0.450
20	0.440	180	0.450
25	0.440	240	0.450



Start water depth for analysis (mbgl)	0.42		
75% effective depth (mbgl):	0.69	Elapsed time (mins):	#N/A
50% effective depth (mbgl):	0.96		
25% effective depth (mbgl):	1.23	Elapsed time (mins):	#N/A
Base of soakage zone (mbgl):	1.50		
Volume outflow between 75% and 25% effective depth (m^3):			
Mean surface area of outflow (m^2):			3.34
(side area at 50% effective depth + base area)			
Time for outflow between 75% and 25% effective depth (mins):			

Soil infiltration rate (m/s):	**Test incomplete as 25% effective depth not achieved. Unable to reliably determine soil infiltration rate.**

Remarks Results processed following BRE 365 (2007).

Client:	Neo Environmental Ltd	**TP3**
Site:	Land at Pempergym	

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