



Dwr Cymru Welsh Water

LLANISHEN AND LISVANE RESERVOIR VISITOR CENTRE

Flood Consequence Assessment





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1 INTRODUCTION

1.1 COMMISSION

WSP were appointed by Dwr Cymru Welsh Water (DCWW) to undertake a Flood Consequence Assessment (FCA) to support the proposed development of the Llanishen and Lisvane Visitor Centre and associated car park at the Llanishen Reservoir, Cardiff.

This FCA focuses on assessing the flood risk issues at the site and includes the following:

- Liaison with Natural Resources Wales (NRW), Cardiff Council (CC) and Dwr Cymru Welsh Water (DCWW) to obtain available information relating to local flood risk issues for the site.
- Identification of all the potential sources of flooding at the site (i.e. fluvial, tidal, highways, groundwater, reservoir, sewers, canal, surface water).
- Consideration of the flood consequence implications, taking into account the potential allowance for climate change over the lifetime of the development and the identification of the measures to mitigate flood risk, if required.

The surface water management and drainage proposals from the proposed development are outside of the scope of this FCA report and are addressed in a separate document prepared by others. The surface water drainage proposals need to be referred to in conjunction with this FCA report in order to understand the surface water management proposals which have been prepared to prevent impact on surface water flood risk elsewhere.

1.2 POLICY CONTENT

This FCA has been prepared in accordance with the relevant national, regional and local requirements and guidance of the following publications and organisations:

- Technical Advice Note (TAN) 15: Development and Flood Risk dated October 2004 issued by Welsh Government
- Cardiff Council
- Building Regulations 2010 (Part H3)
- Sewers for Adoption 7th Edition
- Planning Policy Wales (Edition 9, November 2016) issued by Welsh Government
- Cardiff Council Local Flood Risk Management Strategy, September 2014
- Welsh Ministers Standards for Foul Sewers and Lateral Drains
- The new Sustainable Drainage Systems (SuDS) Manual C753, CIRIA
- RainScape – Dwr Cymru Welsh Water
- SuDS Wales



1.3 PLANNING POLICY WALES AND TECHNICAL ADVICE NOTE 15

The general approach of the Planning Policy Wales (PPW), supported by the Technical Advice Note 15 (TAN15) is to follow a precautionary framework approach when determining the suitability of land for development in flood risk areas, with the intention of steering development away from areas of high risk of flooding to the lowest flood risk areas. The proposed development plan is included in Appendix A of this report.

When development has to be considered in high risk areas (zone C) only those developments which can be justified on the basis of the tests outlined in Section 6 and Section 7 of the TAN15 guidance are to be located within such areas.

Table 2 of TAN15 guidance confirms the 'Flood risk vulnerability classification' of a site, depending on the proposed usage. This classification is subsequently applied to Development Advice Map (DAM) containing three zones (A, B and C with subdivision into C1 and C2) to determine whether:

- The proposed development is suitable for the zone in which it is located.
- The appropriate planning tests that need to be demonstrated in relation to the proposed development.

In accordance with Section 5 and 6 of TAN15 this development should be classed as "other" development' and is an exception to the justification rule because the development is required in a fluvial, tidal or coastal location by virtue of its nature.

It is understood that the Client has agreed with the Planning Authority that a design with a 1 in 100 year+25% standard of protection against fluvial flood risk is required to be achieved for this development.

1.4 LIMITATIONS

The findings and opinions conveyed via this report are based on information obtained from a variety of sources, as detailed, which WSP believes are reliable. Nevertheless, WSP cannot and does not guarantee the authenticity or reliability of the information it has relied upon from these sources.

This report has been written on behalf of the Client and no responsibility is accepted to any Third Party for all or any part. This report should not be relied upon or transferred to any other parties without the express written authorisation of WSP. If any unauthorised third party comes into possession of this report, they rely on it at their own risk and the authors owe them no duty of care or skill. WSP disclaims any responsibility to the Client and others in respect of any matters outside the scope of the above contract.

This report has been prepared by WSP with all reasonable skill and care within the terms of the Contract with the Client and taking into account of the information made available by the Client, as the manpower and resources devoted to it by agreement with the Client. The scope of this FCA and the hydraulic modelling undertaken excludes a reservoir breach assessment.

It should be noted that the insurance market applies different tests to properties in relation to both determining premiums and, more fundamentally, determining the insurability of properties for flood risk. Those undertaking development in areas which may be at risk of flooding are advised to contact their insurers or the Association of British Insurance (ABI) to seek further guidance prior to



commencing development. WSP do not warrant that the advice in this report will guarantee the availability of flood insurance either now or in the future.

The findings of this FCA have been based on data available at the time of the study and on the review of available information that has been undertaken to date. They relate to the current development proposals as outlined in Appendix A. Should the proposed end use of the site change after the completion of this assessment, then the findings of this report will need to be reviewed and updated accordingly.

2 EXISTING SITE AND DEVELOPMENT PROPOSALS

2.1 SITE LOCATION

The proposed Llanishen and Lisvane reservoir development site is located on the outskirts of Cardiff City, approximately 5km north of the city centre, within the ward of Llanishen. The site has an approximate area of 0.70ha and is centred within National Grid Reference 318716E, 182123N.

The site boundary is irregular in shape and is bounded to the north by woodland, to the east by the DCWW Lisvane Reservoir, to the south by the Llanishen Reservoir and to the west by the Nant Fawr ordinary watercourse, beyond which are located a series of allotments and residential properties that front onto South Rise Road. The development site is accessed via the existing reservoir access road that cuts through the woodland to the north of the development and connects to the B4562 Lisvane Road. The existing site location plan is shown in Figure 2.1 below.

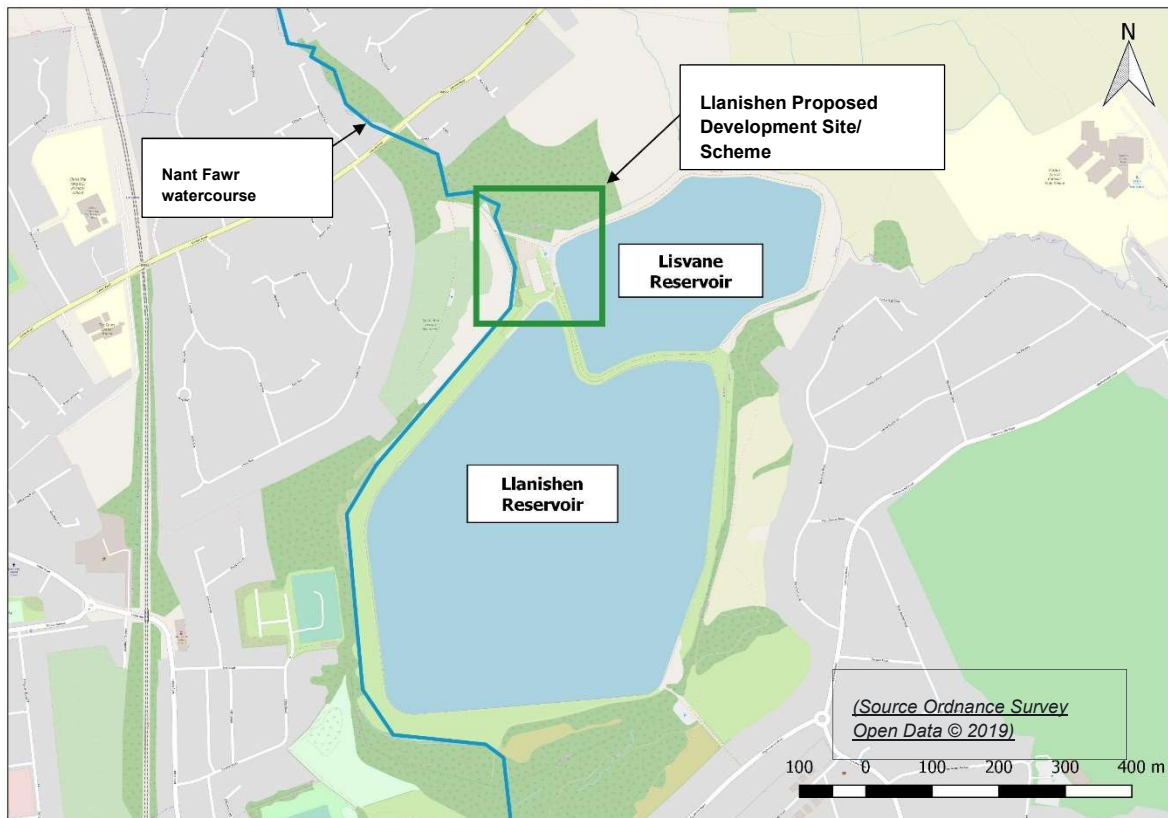


Figure 2-1 - Site Location Plan

2.2 SITE DESCRIPTION

Topographical surveys provided by the Client have been reviewed as part of this assessment and are included in Appendix B of this report. The two surveys completed consist of a topographic spot level survey undertaken by Alpine Land Surveyors in March 2019 and a detailed cross section survey of Nant Fawr watercourse undertaken by Survey Operations in September 2019.

The wider terrain details and topography used in this assessment beyond the extent of the surveys is based on 1.00m resolution (± 150 mm root mean squared error, composite Digital Terrain Model (DTM)),

Light Detection and Ranging (LIDAR) information obtained from the Natural Resources Wales (NRW) Lle portal in September 2019.

The level surveys undertaken indicated the following.

- Ground levels generally fall from the north west to south east across the site (from a high point of approximately 47.78mAOD at the access road site gate, to approximately 45.73mAOD adjacent to the edge of the reservoir).
- The existing access road ground levels generally fall from north to south along its route from approximately 51.20mAOD located at the junction with the B4562 Road to approximately 47.78mAOD at the access road site gate).
- The reservoir top water level (TWL) i.e. reservoir overflow level is 44.63mAOD.
- The surface area of the reservoir at TWL is 78,000m²
- The top of the reservoir embankment is circa 45.70mAOD.
- The maximum height of the reservoir embankment adjacent to the scheme based on the survey is 10.30m.

2.3 PROPOSED DEVELOPMENT

The proposed development is located at Site 2 – Car park and Visitor centre on the DCWW master plan (DCWW 761-01 Feb 2020) provided by the Client and as shown in Figure 2-2 below:

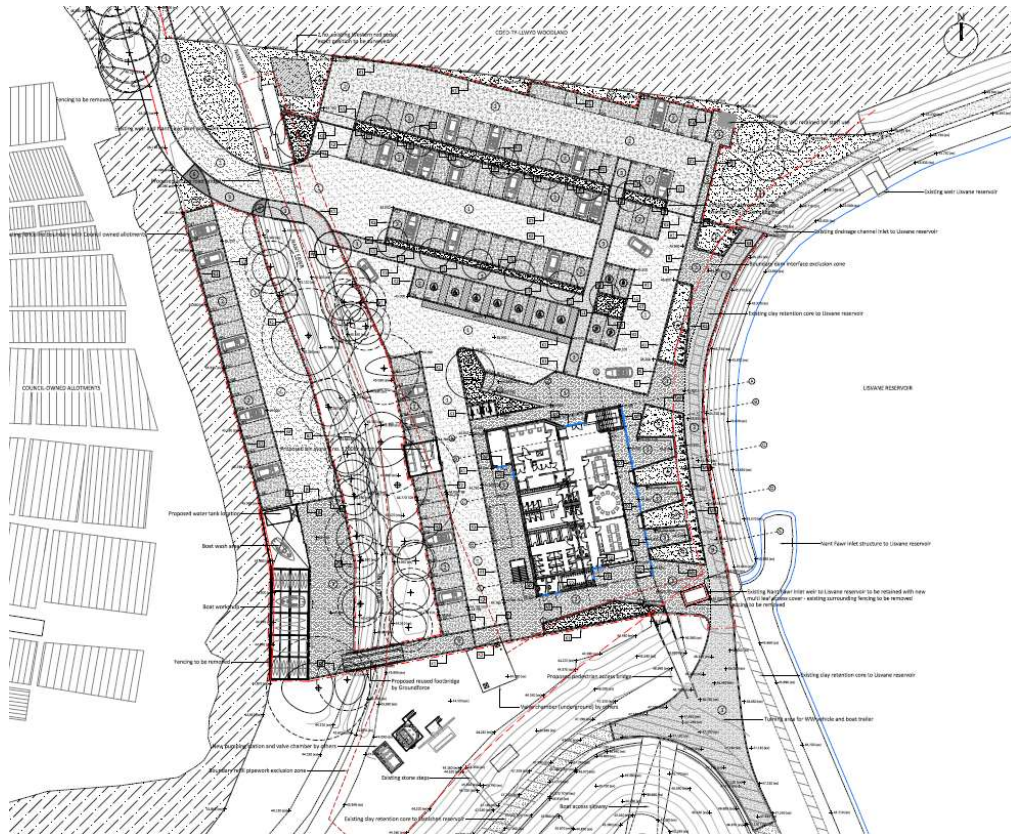


Figure 2-2 – Proposed visitor centre development plan

The assessment considers the visitor centre and car park site enclosed within the red line boundary identified on the Landscape and General Arrangement drawing (**LTD_099(08)101**). The plans have been reviewed as part of this assessment and are included in **Appendix A** of this report.

The proposed development comprises of the construction of a new reservoir Visitor Centre that will serve multiple aims while enabling public access to the reservoir. The centre will also provide recreational water sports and outdoor activities facilities for local residents and visitors.

The new Visitor Centre will be constructed with the following facilities:

- Café / restaurant capable of seating a minimum of 114 covers with external balconies.
- A function room for internal use or hire all served by a kitchen.
- Water sports centre with toilet, shower, changing facilities and training / meeting rooms.
- Office space and sanitary facilities.
- Publicly accessible roof to act as a viewing platform.
- Visitor information centre as part of nature walks and trails around the reservoir accessed via a bridge from the first floor.

The new visitor centre building will be formed from a two-storey steel frame with precast planks at first floor slab level and Kerto timber joists at roof level. Timber clad 'pods' extend the east façade of the building to form viewing points out to the reservoir.

At first floor level, a large terrace is proposed and this extends around the perimeter of the visitor centre to the east and south providing an extension to the restaurant space. The terrace is proposed to be covered by a cantilevering canopy. To the south of the centre, a pedestrian foot bridge is proposed to connect the terrace to the footpaths extending away from the building to the south.

The proposal also includes new landscaping adjacent to the reservoirs, an upgraded vehicular access road and Bridge over the Nant Fawr, visitor and staff car parking for approximately 114 vehicles, hardstanding areas, footpaths, a slipway into Llanishen reservoir and a dedicated boat workshop with wash area for marine vehicle maintenance and repair.

Access and egress from the proposed development will remain as existing, i.e. from the B4562 Lisvane Road located to the north of the site.

The finished floor levels of the proposed building will be set at 45.10mAOD. As part of the redevelopment, the proposed external ground levels on the remainder of the site will vary between 44.818mAOD and 45.750mAOD. These changes in ground levels have been used to assess the changes in flood risk in the hydraulic model and this is discussed in Section 4 of this report.

2.4 GEOLOGY & HYDROGEOLOGY

The geology of the site has been reviewed from the British Geological Survey (BGS) online geology maps and the following reports provided by the Client:

- Geotechnics Ground Investigation Report, carried out at Llanishen Reservoir, Cardiff Phase 3 Draft Interpretive report, March 2019

A desktop review was undertaken using the British Geological Survey (BGS) online geology maps. The BGS records report that the site is underlain by the following:

- *Superficial Geology: No superficial deposits are shown overlying the bedrock*

- *Bedrock Geology: Maughans Formation - Argillaceous Rocks And [subequal/subordinate] Sandstone, Interbedded. Sedimentary Bedrock formed approximately 393 to 419 million years ago in the Devonian Period. Local environment previously dominated by rivers.*
- *The depth of groundwater beneath the site is unknown.*
- *The bedrock deposits are Secondary A Aquifers. Secondary A Aquifers (alluvium, sand and gravel deposits, Salop Formation) – sediments/rocks with permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.*
- *The site is deemed to have a High groundwater vulnerability.*
- *No licenced groundwater abstractions have been identified within 1km of the site and the site is not located within a Source Protection Zone.*

The Geotechnics ground investigation reports the following:

- *The site comprises a level, open space consisting of a former compound area, the ground surface comprising brown clay and stone. Access is in the north eastern corner via a rolled stone track. The site is bounded to the east by a grassed bund beyond which lies Lisvane Reservoir.*
- *Based on the Borehole log findings the ground can be classified into the various strata defined in the investigation as the following:*
 - *Made Ground / Topsoil*
 - *Probable Made Ground*
 - *Superficial Deposits (Cohesive)*
 - *Superficial Deposits (Granular)*
 - *Superficial Deposits / St Maughan's Formation*
- *Groundwater was encountered in all the boreholes during drilling. It was found at depth of 1.20m in the Superficial Deposits (Cohesive) in BH04, no rise in level being noted after a 20 minute pause in the drilling operations. It was also found at depths of between 2.80 and 5.00m below ground level (bgl) in the Superficial Deposits (Granular) in the other boreholes, the levels rising to between 1.00 to 4.50m bgl after 20 minutes.*
- *Ground water Standpipes were installed in BH01 and BH03 with filter zones covering the Cohesive and Granular Superficial Deposits. Maximum groundwater levels of 0.60m bgl and 0.44m bgl were recorded over the monitoring period.*

The scope of the March 2019 ground investigation did not include BRE365 soakaway tests; further testing undertaken in October 2019 indicated insufficient infiltration at the testing locations to reliably determine the soil infiltration rate for the development site.

2.5 SOILS

Cranfield University Soilscape Viewer was reviewed to determine soils across the development area. The site is predicted to consist of Slightly acid loamy and clayey soils. These soils are classified as having slightly impeded drainage which refers to soils with a tight, compact deep subsoil that impedes downward water. After heavy rainfall, particularly during the winter, the subsoil becomes waterlogged and results in very wet ground conditions.

2.6 HYDROLOGY

The Nant Fawr “Ordinary Watercourse” flows in a general south easterly direction alongside the reservoir access road and through the wooded area approaching the northwestern boundary of Llanishen Reservoir. Adjacent to the main development area, the watercourse changes direction and heads in a southwesterly direction around the western side of Llanishen Reservoir (Figure 2-3).



Figure 2-3 - Hydrology Map

The 2019 topographical survey indicated that, within the wider reservoir site, the Nant Fawr watercourse is culverted at certain locations. The survey also indicated there is a series of pipes, bridge crossings and river flow control structures. These flow controls retain the Nant Fawr flows in channel and may have been historically used to divert / receive flows into and from the Llanishen Reservoir. The hydrological features are shown in Figure 2-4 below:

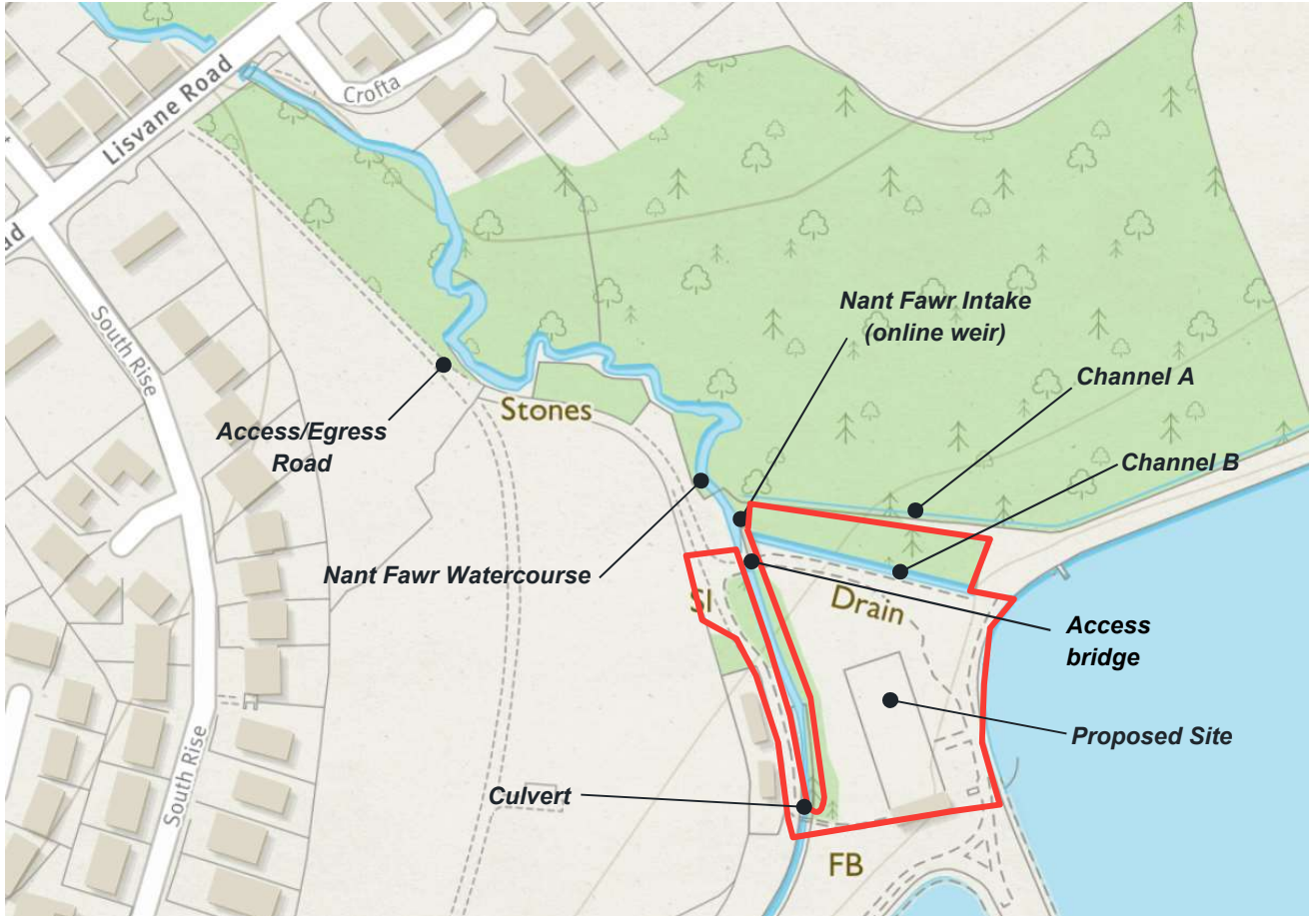


Figure 2-4 - Site Hydrology Map

(Contains OS Data © Crown Copyright and database right 2020)

At the entrance of the main development area, the access road crosses the watercourse close to the Nant Fawr intake flow control structure (online weir). There are two open channels (Channels A and B) that are believed to be used as historical bypass channels for Nant Fawr watercourse to enable works on the intake structure (Figure 2-5).



Figure 2-5 - Nant Fawr Intake Structure

2.7 EXISTING DRAINAGE ARRANGEMENTS

2.7.1 EXISTING SITE DRAINAGE

The 2019 topographic and utility survey (LEWIS/LR/001) provided by the Client (Appendix B) indicated an existing 300mm drain located to the east and south of the site. It is assumed this is an existing surface water drain serving the site, although it is recommended that this is further investigated before detail design.

2.7.2 PUBLIC SEWERS

A copy of DCWW's sewer records has been reviewed as part of this assessment and is included in Appendix C of this report. The sewer records indicated the presence of a combined sewer that flows in a southerly direction and which is located to the west of the site (adjacent to the access track).

There is a surface water sewer which is located to the southwest of the site. This surface water sewer discharges into the Llanishen Reservoir.

2.8 CONSULTATION WITH STATUTORY AUTHORITIES

2.8.1 CONSULTATION WITH CARDIFF COUNCIL (CC)

The Lead Local Flood Authority (LLFA) and SuDS Approval Body (SAB) of CC has been consulted as part of this assessment. The following relevant information was provided following the consultations:

- *We hold no relevant information relating to this area, but are aware from EA/NRW flood maps that it is impinged by design storm events.*
- *Whilst as a Planning Authority CC, we will still respond to any FCA, CC will consider the site from the perspective of a SAB (SuDS Approval Body)*
- *Flood zone maps show that approx. 75% of the car park is currently within flood zones.*

2.8.2 CONSULTATION WITH NATURAL RESOURCES WALES (NRW)

Consultation has been undertaken with NRW and this section summaries the relevant development specific responses from the engagement exercise undertaken:

- *NRW are not aware that there are any historical flooding records for the site.*
- *NRW advised that the development will need to be designed to be flood free in the 100 year + CC allowance.*
- *NRW advised that there is a risk of the reservoir flooding, NRW identified that whilst there is a risk, this is a well-managed risk and therefore this detail should be included within the FCA and discussed.*
- *DCWW confirmed there is no interaction / connectivity between the reservoir and the water course.*
- *Llanishen reservoir is currently disused and was dry until recently, but being restored by DCWW with a view to fill it up gradually.*
- *NRW have provided the following table with the design details of the two reservoirs:*

	Capacity (m ³)	Surface Area (m ²)	TWL (mAOD)	Max Height (m)	Crest Length (m)	Dam Crest (mAOD)
Llanishen	1,441,000	240,400	46.015	11.00	1,966	47.18
Lisvane	363,636	78,000	44.63	10.30	1,177	45.83

2.8.3 CONSULTATION WITH DWR CYMRU WELSH WATER (DCWW)

The pre-planning advice received from DCWW can be summarised as follows:

- There are no flood defences on the small watercourse [Nant Fawr].
- Top water level, i.e. overflow level of the Lisvane Reservoir is 44.63mAOD. DCWW do not think the retained volume below this is relevant as the reservoir will be at TWL or higher during and flood events.
- DCWW believe the top of the embankment of the Lisvane Reservoir is circa 45.70m AOD - see drawing LTS_099(08)101 – Landscape General Arrangement, with a surface area at TWL of 78,000m².
- The open ditch channel (at Nant Fawr Inlet) is redundant infrastructure and does not carry flow from the Nant Fawr or the Lisvane Reservoir.
- DCWW have ruled out any future use for the ditch as part of an overflow from Lisvane and it has no use in the Llanishen schemes either. DCWW believe it may possibly have been used previously to bypass the Nant Fawr and enable works on the intake structure.
- The Nant Fawr intake is the main source of water to the Lisvane / Llanishen reservoir and is normally used 365 days of the year.
- The previous above ground use of the land of the visitor centre footprint included part of a boat storage yard and green space. There were some old pipes running under that area which the current project should have identified the correct location or removed.
- DCWW Reservoir safety engineer comment - they have no knowledge of historical flooding from reservoir.

3 ASSESSMENT OF FLOOD RISK

3.1 FLOODING HISTORY

NRW, CC and DCWW were consulted regarding historic flooding in this area. There is no record of historic flooding from any of these sources.

3.2 FLUVIAL FLOOD RISK

The NRW’s fluvial flood risk maps indicate that the western part of the site is situated within Flood Zone C2 (see Figure 3-1). The source of the predicted flooding is from the nearby watercourse, the Nant Fawr, which is located to the west of the site.



Figure 3-1 - NRW Fluvial Flood Risk Map

Flood Zone C2 is the “*extent of a flood from rivers or from the sea with up to a 0.1% (1 in 1000 chance of happening in any given year)*”. Flood Zone C2 is also known as “*Areas of the floodplain without significant flood defence infrastructure*”.

A hydraulic model has been developed by WSP for the area to assess the risk of fluvial flooding in more detail. The findings of the hydraulic modelling and the assessment of the fluvial flood risk from the Nant Fawr is included in Section 4 of this report.

3.3 SURFACE WATER FLOODING

Surface water flooding occurs because of rainwater not being able to drain away through the normal drainage systems or infiltrate into the ground. It therefore lies on or flows over the ground instead. NRW define “High”, “Medium” and “Low” surface water flood risk as:

- “Low” risk means that each year, the area has a chance of flooding between 1 in 1000 (0.1%) and 1 in 100 (1%).
- “Medium” risk means that each year, the area has a chance of flooding between 1 in 100 (1%) and 1 in 30 (3.3%).
- “High” risk means that each year, this area has a chance of flooding of greater than 1 in 30 (3.3%).

According to NRW’s Flood Risk Maps for surface water (Figure 3-2), the site is currently at a “Low” risk of surface water flooding. It has to be noted that the local surface water flood outline also ties in with the fluvial floodplain of the Nant Fawr and it may therefore show some inaccuracies in the available NRW data online.

The proposed development will include a positive drainage system to serve the site with appropriate on-site attenuation and flow controls to manage surface water flood risk on site to the proposed buildings and to the adjacent sites. Following the proposed development, with the inclusion of surface water drainage systems on site, the risk of surface water flooding to the site will be “Very Low”. The surface water drainage scheme will also ensure that there will be no increase in flood risk from the proposed development to adjacent sites. This will be achieved by controlling the rate of discharge of the surface water runoff from the site into the Nant Fawr.

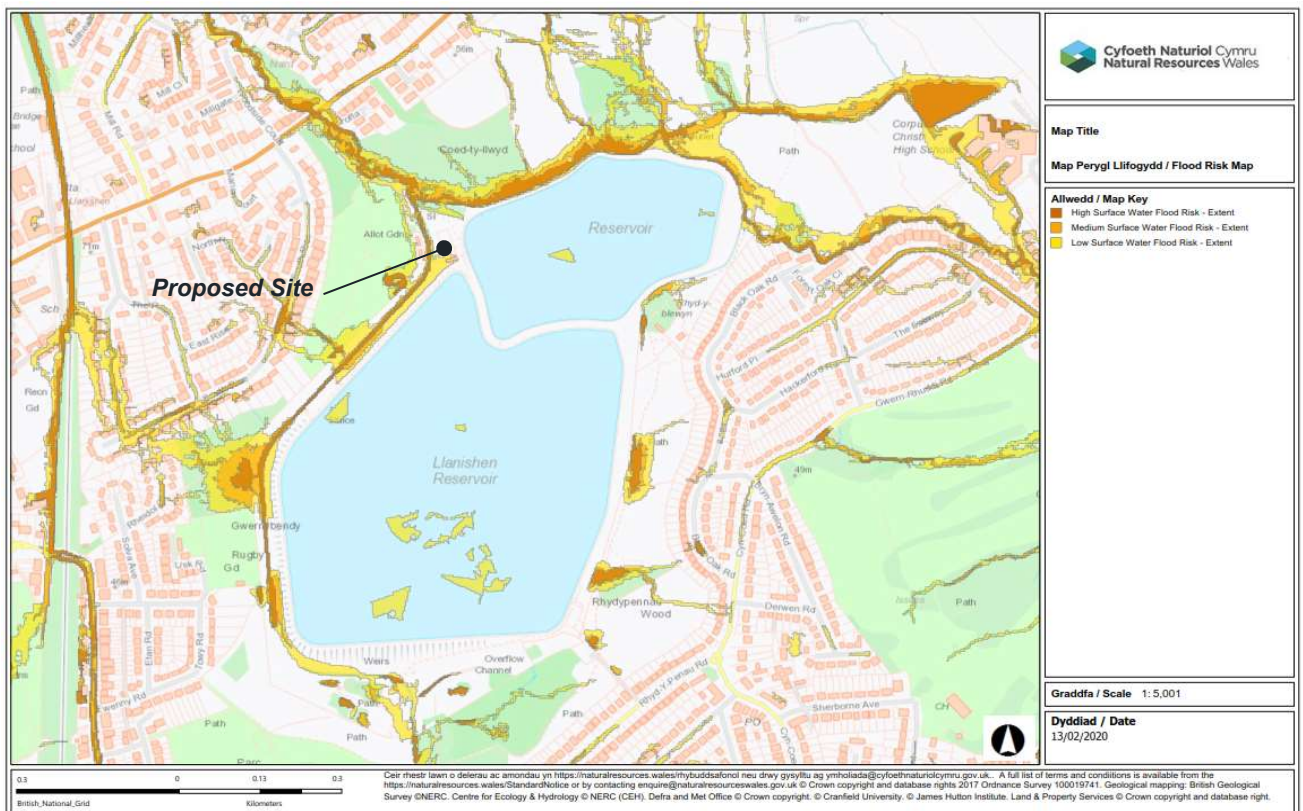


Figure 3-2 - Surface Water Flood Risk map (source NRW website, February 2020)

3.4 FLOODING FROM THE SEA

The site is located inland and is not within proximity of a tidally influenced watercourse. On this basis, the risk of flooding from the sea or high tides to the proposed development is “Negligible”.

3.5 FLOODING FROM CANAL

There are no canals within the vicinity of the site. On this basis, the risk of canal flooding to the proposed development is considered to be “Negligible”.

3.6 GROUNDWATER EMERGENCE AND FLOODING

Groundwater flooding is caused by unusually high groundwater levels. It occurs as excess water emerging at the ground surface or within manmade structures such as basements. Groundwater flooding tends to be more persistent than surface water flooding, in some cases lasting for weeks or months, and can result in significant damage to property. The risk of groundwater flooding depends on the nature of the geological strata underlying the site, as well as on local topography.

The ground investigation results provided by the Client have indicated that the ground water level was between 1.00m and 1.20m bgl. The ground investigation also identified groundwater in the superficial deposits between 2.80m bgl and 5.00m bgl rising to between 1.00 to 4.50m bgl after 20 minutes.

Groundwater standpipes were installed in BH01 and BH03 with filter zones covering the Cohesive and Granular Superficial Deposits. Maximum groundwater levels of 0.60m bgl and 0.44m bgl were recorded over the monitoring period.

There are no proposed cellars or below ground level rooms as part of the proposed development. The risk of groundwater flooding is therefore assessed to be “Low”. It is also recommended that further long term testing/monitoring is undertaken of the groundwater movement to ascertain any residual risk and inform and any mitigation measures required within the design of the proposed building.

3.7 FLOODING FROM RESERVOIRS

The NRW’s reservoir flood risk maps indicate that the development site is situated within the Reservoir Flood Zone (see Figure 3-3 and 3-4). The source of the flooding is predicted to be from the adjacent reservoirs.

The current NRW reservoir flood map (depth) shows the largest extent and predicted depth of flooding that might occur if a reservoir were to fail (breach and/or overtopping) and release the water it holds.

A comparison of the existing Lisvane Reservoir, its dam crest level of 45.83mAOD, the TWL of 44.63mAOD and the proposed building level of 45.10mAOD would indicate that the risk of inundation for the proposed building from this reservoir is “Low”.

The Llanishen Reservoir is currently being restored and filled up. The dam crest level of the Llanishen reservoir is at 47.18mAOD and the TWL of 46.015mAOD. These figures would indicate that the proposed development site may be at “Medium” risk of flooding from the Llanishen Reservoir in case of an overtopping or breach.

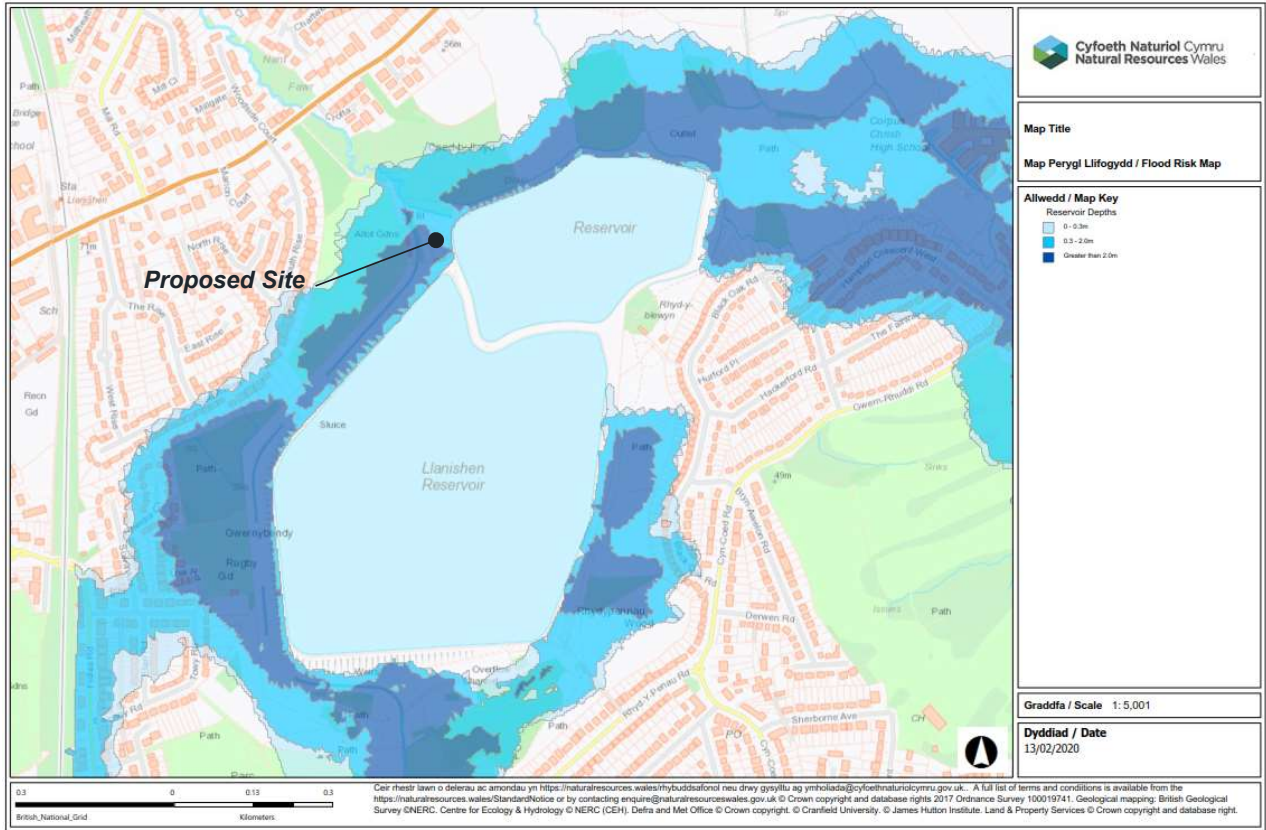


Figure 3-3 - Reservoir Flood Risk (Depth Map)

The reservoir flood risk map (velocity) outline shows the maximum flood speeds that might be expected if a reservoir were to fail and release the water it holds. The scope of this FCA and the hydraulic modelling undertaken excludes a reservoir breach assessment.

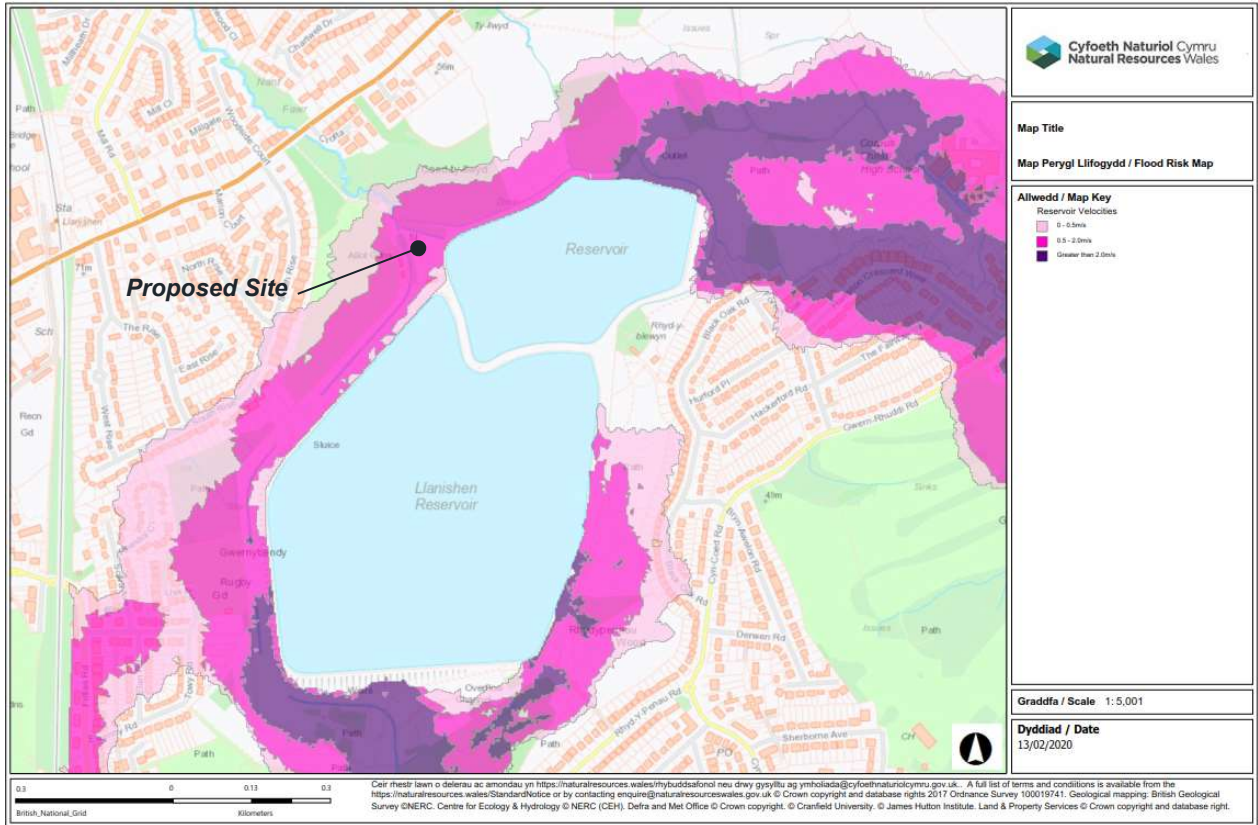


Figure 3-4 - Reservoir Flood Risk (Velocities Map)

Due to the location and close association of the proposed development with the wider reservoir sites, the development currently falls within the reservoir flood risk map shown. It is recommended that proposed development includes reservoir flood warning alert measures, for example, to prevent access to the site during storm events or following the identification of a potential overtopping or reservoir breach scenario.

Emergency evacuation measures should also be in place in order to manage the risk to site users in the event of a reservoir flood emergency.

Reservoirs are inspected and managed by the asset owner and the risk of breach and /or inundation are also very well monitored by the DCWW. In the event of a risk of inundation or breach, the visitor centre and car park areas are recommended to be closed to the public to minimise any flood risk impacts. The site owner and operator are required to keep up to date with the flood warnings and alerts in place.

3.8 FLOODING FROM SEWERS

Consultation has been undertaken with DCWW regarding the sewer flood risk they have stated that within the site:

- *DCCW hold no relevant information relating to this area, but are aware from EA/NRW flood maps that it is impinged by [fluvial] design storm events.*



The public combined sewer is located to the west of the site and the Nant Fawr. The surface water sewer is located to the south west of the site and this is shown to discharge into the Llanishen Reservoir.

Given the location of the surface water and combined sewers, it is unlikely that the proposed visitor centre site will be affected by flooding from these sewers and the risk of sewer flooding is considered to be “Very Low”.

3.9 FLOODING FROM HIGHWAY

At this stage, there is no detailed highway drainage survey information serving this site, the access road, or the adjacent B4562 highway to the reservoir site. Consultations undertaken with CC have indicated the following:

- *There are no known highway flooding issues.*

A review of the topographical survey and LIDAR data shows that the majority of the site to be lower than road levels along B4522 Lisvane Road. There are formal highway drainage systems in the form of surface water road gullies on the B4522 Lisvane Road. The above indicates the presence of existing measures to minimise the risk of highway drainage flooding to the site from the nearby roads.

The existing rolled stone access track to the site is believed to be served by over the edge drainage into the Nant Fawr watercourse. It is recommended that any proposed access track to the development includes measures to adequately manage the runoff from the road towards the development. Any road drainage proposal must ensure that they are fully operational and maintained properly to prevent any flooding onto the proposed development site.

On the basis of the above, the risk of highway flooding to the proposed development is considered to be “Low”.

4 SUMMARY OF HYDRAULIC MODELLING

4.1 NANT FAWR HYDRAULIC MODEL

As part of the preparation of this FCA, WSP have obtained the existing Natural Resources Wales (NRW) hydraulic model for Roath Brook and updated the relevant sections of Nant Fawr. The extents of the WSP hydraulic model are shown in Figure 4.1 below:

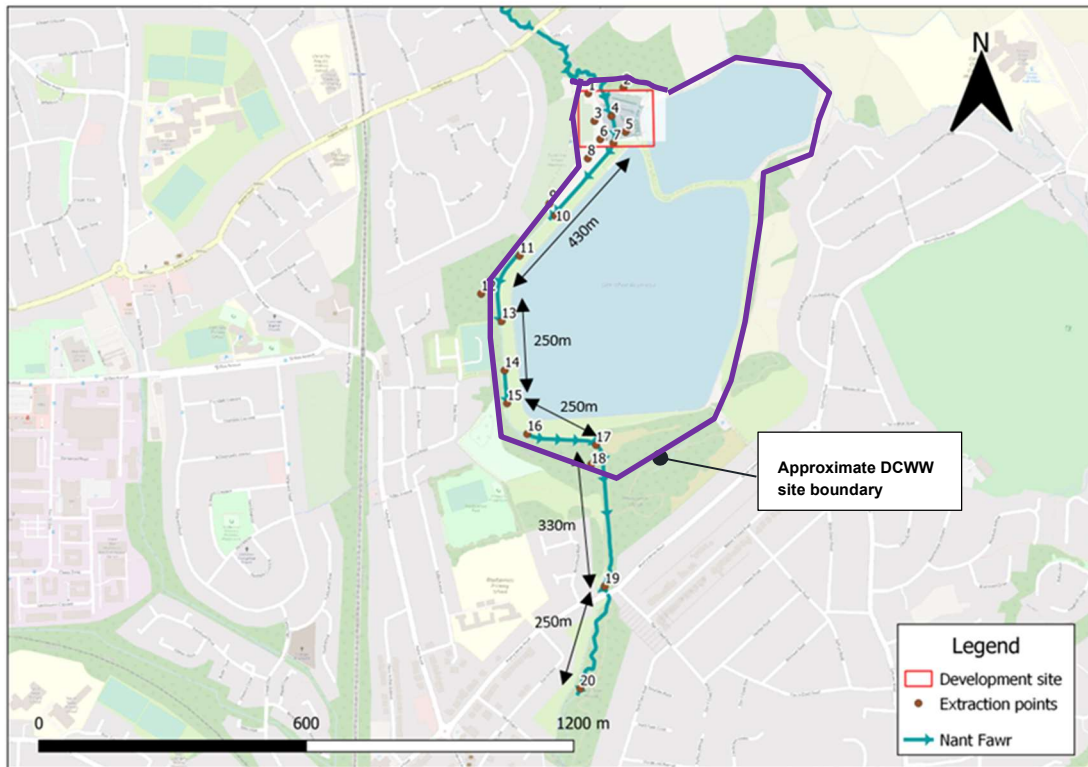


Figure 4-1 – Extents of WSP Hydraulic Model for Nant Fawr

As can be seen from the above, the WSP model of the Nant Fawr watercourse extends approximately 1500m from the proposed visitor centre development site. The downstream extent of the WSP model is located approximately 600m from the overall site ownership boundary of DCWW. The above model extents were developed in agreement with NRW.

The objectives of the hydraulic modelling update were to:

- Review the available NRW hydraulic model;
- Update the NRW hydraulic model of the Nant Fawr with the inclusion of the latest topographical and river survey data;
- Carry out hydrological analysis and update the model inflow in accordance with NRW's requirements;
- Develop the existing baseline model scenario (update the existing 1D model into 1D - 2D linked model using Flood Modeller Pro-TuFLOW);

- Build the proposed scenario hydraulic model;
- Assess the fluvial flood risk before and after the proposed development.

WSP have consulted with NRW to discuss and agree the methodology, extents and the requirements for the baseline model and the proposed scenario model.

The hydraulic modelling has been undertaken to provide flood risk information for the following:

- Baseline model (existing scenario)
- Proposed scheme scenario
- Sensitivity analysis for
 - Manning's roughness (20% decrease and 20% increase in Manning's "n" coefficient)
 - Downstream boundary conditions (20% decrease and 20% increase in downstream boundary depth)
 - Flow (20% decrease and 20% increase in flow)
- Blockage scenarios (Low - 30%, Medium - 67% and High - 95% blockages)
- Changes in Flow velocity and Flood Hazard

The hydraulic modelling report contains the full description of the agreed methodology, the extent of the model and the different scenarios analysed. The findings and the flood maps are presented in Appendix D of this report. These can be read in conjunction with this Section.

4.2 SUMMARY OF FINDINGS OF HYDRAULIC MODELLING

Further to the completion of the hydraulic modelling of a wide range of scenarios (the baseline, proposed scheme, sensitivity and blockage scenarios) at different return periods, the findings have been summarised in this section. Reference should be made to the hydraulic modelling report and the flood maps included in Appendix D.

4.2.1 BASELINE SCENARIO

The findings of the baseline scenario are as follows:

- The Baseline Scenario simulations showed increases in water levels within the channel upstream of the online weir located at the main entrance of the proposed scheme site. Due to this, the flow was noted to overtop the left banks and flow through the existing channels (Channel A and B) near the Lisvane Reservoir. This flood mechanism is predicted to occur in events of 5% AEP (1 in 20-year return period) and greater.
- The flow was noted to overtop the right bank of the channel and flood the South Rise Leisure Allotments during the 1% AEP (1 in 100-year return period) and greater.
- The model results showed that, in the baseline scenario, the maximum flood depths at the location of the proposed building are 0.02m and 0.79m at 1%AEP +25%CC and 0.1%AEP events respectively.

4.2.2 PROPOSED SCHEME SCENARIO

The findings of the proposed scheme scenario are as follows:

- The flow was noted to overtop the left banks of the Nant Fawr at the 5% AEP (1 in 20 year return period) and greater events (similar to the Baseline Scenario), upstream of the online weir. This water then started to flow along the Channel A.
- The flows were noted to overtop the right bank and flood the South Rise Leisure Allotments during the 1% AEP (1 in 100 year return period) and greater.
- The model results do not show any flooding risk to the proposed building up to the 1% AEP. However, a small part of the site within the red line boundary, located to the north of the proposed parking area is likely to be flooded with water depths up to 20mm in the 1% AEP event.
- The proposed building floor level is 45.10mAOD. The model results show that the proposed building is unlikely to be affected by fluvial flooding during the 1%AEP +25%CC event (the agreed design criteria). The flood depth during the 0.1%AEP event would be 0.19m.
- The maximum flood depths within the external areas within the red line boundary of the development site were noted to be between 0.05m and 0.49m for the 1%AEP+25%CC and 0.1%AEP events respectively.

The following Table 4-1 shows a summary of the differences in flood depths at various node locations 1 to 20 along the WSP model extent.

Table 4-1 – Comparison of depth at various model node locations

Impact Assessment Number	Impact Assessment Location	Depth (m)		
		Baseline (m)	Scheme (m)	Depth Difference - New Baseline and Scheme (m)
1	Floodplain	0.00	0.00	0.00
2	Floodplain	0.17	0.17	0.00
3	Floodplain	0.01	0.01	0.00
4	Channel (NANT_030)	1.92	1.94	0.03
5	Floodplain	0.00	0.00	0.00
6	Floodplain	0.02	0.02	0.00
7	Channel (ROAT01_7162)	1.76	1.94	0.17
8	Floodplain	0.04	0.04	-0.01
9	Floodplain	0.43	0.60	0.17
10	Channel (ROAT01_6889U)	3.17	3.34	0.17
11	Channel (ROAT01_6783D)	1.86	1.94	0.08
12	Floodplain	0.71	0.79	0.08
13	Channel (ROAT01_6612U)	2.36	2.44	0.08
14	Channel (ROAT01_6508D)	1.24	1.25	0.02
15	Channel (ROAT01_6431U)	1.31	1.33	0.02
16	Channel (ROAT01_6346D)	0.85	0.86	0.01
17	Channel (ROAT01_6186U)	0.73	0.74	0.01
18 (downstream extent of DCWW boundary)	Floodplain	0.00	0.00	0.00
19	Channel (ROAT01_5841U)	0.99	0.99	0.00
20	Channel (ROAT01_5557)	0.99	0.99	0.00

As can be seen from the above table, the proposed development does not adversely affect the flood risk downstream of the DCWW land ownership within the extent of the WSP model.

Figure 4-2 below shows a comparison of the floodplains for the 1%AEP+ 25% climate change event.



Figure 4-2 – Comparison of baseline and proposed scheme flood extents (1% AEP +25% climate change event)

4.2.3 SENSITIVITY ANALYSIS

The findings of the sensitivity analysis are summarised as follows:

- The water levels remained unaltered in the reach of proposed development when the downstream boundary depth was increased or decreased by +/- 20%. Therefore, the model showed that the changes in downstream boundary did not affect the proposed building site.
- The maximum increase and decrease in water levels were between 0.19m and 0.27m with 20% increase and decrease in flows respectively.
- Water levels increased in the range of 0.019m to 0.105m depending upon the location in the model reach when the Manning's "n" roughness values were increased by 20%. The water levels decreased in a range of 0.013m to 0.103m in the model reach with the 20% decrease in roughness value.
- The model showed that, at certain locations, the model was comparatively more sensitive to both increase and decrease in the Manning's n" roughness value. However, the changes in roughness did not affect the proposed building site.

4.2.4 BLOCKAGE SCENARIOS

4.2.5 The blockage for the development scenario results showed that the maximum flood depths for the areas of the proposed development within the red line boundary are as follows:

- Low (30%) blockage scenario, maximum water level 45.04 m AOD (0.25m depth),
- Medium (67%) blockage scenario, maximum water level 45.02mAOD (0.23m depth), and

- High (95%) blockage scenario, maximum water level 44.94 mAOD (0.15m depth).

On the basis of the blockages scenario results, the proposed building (with a FFL of 45.1mAOD), the proposed visitor centre building is unlikely to be affected by fluvial flooding in the Low, Medium and Maximum blockage scenarios.

4.2.6 FLOOD RISK IMPACT ELSEWHERE

Comparisons of the results of the baseline scenario and the proposed scheme have been undertaken at the various model node locations (nodes 1 to 20) as shown on Figure 4.1. These comparisons have taken into account the changes in flood depths and the flow velocity at those 20 locations, calculated and analysed in accordance with the guidance provided by NRW (Modelling for Flood Consequence Assessments Reference number: GN028).

It was noted that there were some marginal changes in flood depths and flow velocity as a result of the changes in the ground profile as part of proposed visitor centre development site. These changes in flood depths and flow velocity, however, were noted to occur within the boundary of DCWW property, i.e. upstream of model node location 18. There were no changes noted in flow depths (measured to 2 decimal places) and flow velocity (measured to one decimal place) at node locations 18, 19 and 20, which are located downstream of the DCWW land ownership boundary and between 900m to 1500m downstream of the proposed visitor centre development respectively.

The above comparison also indicated that any changes in flood levels as a result of the proposed development would be adequately attenuated within the DCWW land ownership such that there are no increases in fluvial flood risk as far downstream as the extents of the WSP model (upto 1500m downstream of the proposed visitor centre development). This is also demonstrated by the flood maps prepared as part of the hydraulic modelling for this scheme and which are presented in Appendix D of this report. They show representations of the before and after development flood maps showing the changes in flood extents in the study area, as well as relevant flood depths. The flood maps and flood hazards maps prepared also confirm the above findings.

On the basis of the above, and in accordance with the NRW GN028 guidance, it can be concluded that there are no reported changes to flood depth and flow velocity within the WSP model extent (approximately 600m downstream of the DCWW land ownership) as a result of the proposed visitor centre development.

4.2.7 FLOW VELOCITY AND FLOOD HAZARD

A comparison of the flow velocity has been undertaken at certain model node locations and is summarised in Table 4.2 below:

Table 4-2 – Comparison of flow velocity at key model node locations

Impact Assessment Number	Impact Assessment Location			
		Baseline (m/s)	Scheme (m/s)	Flow velocity Difference (m/s)
16	Channel (ROAT01_6346D)	2.2	2.2	0.0
17	Channel (ROAT01_6186U)	2.6	2.6	0.0
18 (downstream extent of DCWW boundary)	Floodplain	0.00	0.00	0.0
19	Channel (ROAT01_5841U)	1.4	1.4	0.0
20	Channel (ROAT01_5557)	1.8	1.8	0.0

As can be seen from the above comparison table, there is no reported change in the flow velocity downstream of the DCWW land ownership up to node 20.

As part of this hydraulic modelling an assessment of the flood hazard rating has also been undertaken. Guidance on the flood hazard ratings is given in the following document:

- EA Risks to people phase II (Defra/Environment Agency R&D project FD2321 (Defra/Environment Agency, 2005))

Table 4.3 below outlines the flood hazard rating that floodwaters present to people (and to vehicles and property). The term ‘hazard’ is as described in Section 3 of the above document as a combination of the following:

- The likely extent of flooding
- Depth of flooding
- The direction and speed of flow
- The probability of the floods occurring

Table 4.3 below has been reproduced from the above guidance document and it summarises the different hazard ratings and their descriptions:

Table 4-3 - Hazard to People as a Function of Velocity and Depth

Hazard Rating	Description
< 0.75	Low (Caution) <i>“Flood zone with shallow flowing water or deep standing water”</i>
0.75 – 1.25	Moderate (Danger for Some) <i>“Danger: Flood zone with deep or fast flowing water”</i>
1.25 – 2.0	Significant (Danger for Most) <i>“Danger: flood zone with deep fast flowing water”</i>
>2.0	Extreme (Danger for All) <i>“Extreme danger: flood zone with deep fast flowing water”</i>

In accordance with the NRW guidance GN028, the comparison of the hydraulic modelling results for the baseline and proposed scenarios have shown that there was no increase in the flow velocity and flood depth downstream of the DCWW development boundary for the 1%AEP+25% climate change allowance events. The 0.15m/s flow velocity noted at the site lies within the tolerable limits for this type of development and also complies with the requirements of Section A1.15 of TAN15.

There was no change in the flood hazard rating at the site when comparing the baseline scenario and the proposed development scenarios during the 1%AEP plus 25% climate change allowance events. The proposed building was noted to lie within an area with the “Low” flood fluvial flood hazard rating. This is shown on Figure 4-3 below.



Figure 4-3 – Comparison of baseline and proposed scheme flood extents (1% AEP +25% climate change event)

4.2.8 FINISHED FLOOR LEVELS

The following Table 4.4 summarises the maximum water levels and flood depths at the proposed building area during different scenarios.

Table 4-4 - Maximum water levels at the proposed building area

Event	No blockage			Low Blockage	Medium Blockage	High blockage
	Q100	Q100+25CC	Q1000	Q100+ CC		
Modelled Building level (mAOD)*	45.100	45.100	45.100	45.100	45.100	45.100
Maximum water level (proposed building) (mAOD)	-	45.039	45.287	45.040	45.040	45.028
Difference -Flood depth (m)	-	-	0.187	-	-	-

On the basis of the findings of the hydraulic modelling report, the proposed building with a FFL of 45.1mAOD is unlikely to be affected by the design flood return period of 1%AEP+25% climate change.

In accordance the requirements of the Section A1.14 of TAN15, the proposed floor level of the visitor centre building will be set above the modelled 1% (plus 25% climate change allowance) threshold frequency of fluvial flooding from Nant Fawr. The proposed building will also be outside the floodplain of the highest blockage scenarios modelled for the 1%AEP plus climate change allowance event.

The proposed floor level therefore satisfies the TAN15 criteria in Section A1.14.

Section A1.15 of TAN15 requires development of this type to have flood depths of less than 600mm in flood events higher than the prescribed threshold frequency.

In this case, the hydraulic modelling has also demonstrated that the external flood depths for events upto the 1000year event will be less than 600mm outside the building and its access and egress routes. This demonstrates that the proposed external ground levels are in compliance with Section A1.15 of TAN15.

5 FLOOD RISK MANAGEMENT MEASURES

5.1 BUILDING FLOOD RESILIENCE MEASURES

5.1.1 THRESHOLD LEVELS

When designing a new building or modifying an existing structure within an area within a flood risk zone, considerations should be taken to provide a threshold or finished floor level above the identified flood level of that particular area to mitigate water entry to the building. In accordance with Document M of the Building Regulations (England and Wales), it states that 'reasonable provision shall be made for people to gain access to and use the building and its facilities', however subject to the existing and proposed site topography, this may not be reasonably practicable. The proposed floor level of 45.10mAOD will ensure that the proposed scenario development is unlikely to be affected by the fluvial 1 in 100year and 25% climate change events.

5.2 SAFE ACCESS AND EGRESS

The development site is accessed via the existing reservoir access road that cuts through the woodland to the north of the development and connects to the B4562 Lisvane Road. In the event of a flood risk emergency the site would be closed to the public and therefore this would limit potential risk to public. The existing access route will be used as the main access route for emergency vehicles and egress for all site users.

The access/egress route is shown in Figure 5.1 below:

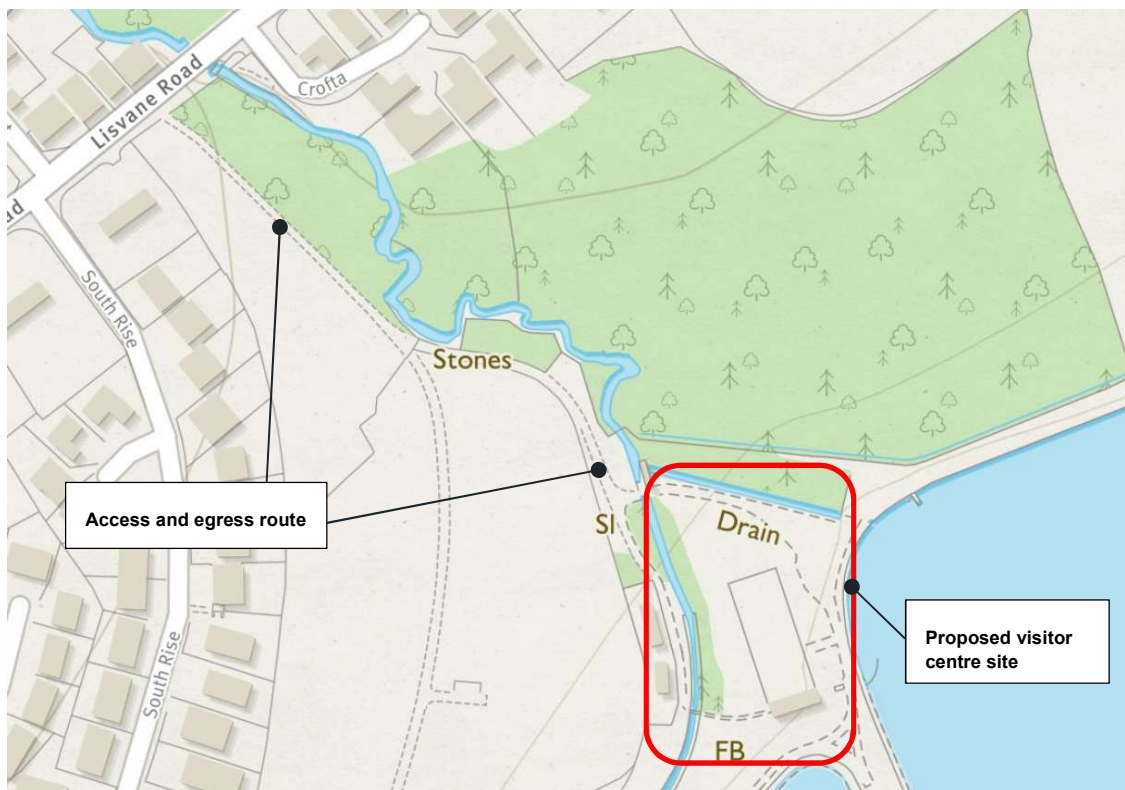


Figure 5-1 – Access and egress route to visitor centre

A review of the DEFRA/EA FD2321/TR2 provides information stating that regular vehicles such as cars will float and stop in water depths exceeding 0.5m, and emergency vehicles in excess of 1m of still flood depth. It is therefore necessary to provide appropriate signage across the proposed car parking area to warn of this flood risk. If the occurrence of an extreme flood event is probable, then the car park is to be closed for use and vehicles should be directed to move to higher ground and away from the site, so as to ensure they do not become a hazard and hinder the emergency vehicle access.

It should also be noted that there are no proposed habitable rooms in this development.

5.3 FLOOD EVENT ACTION PLAN

It is recommended that the development should have a flood event action plan in place to provide occupiers with the correct procedure if a flood is anticipated. The following list includes the main requirements of a flood event action plan:

- The site to be closed to the public.
- Monitoring of flood risk through media and floodline warnings direct
- Flood warning signage in place including severity (including Welsh language)
- Audible and visual flood alert systems within the premises
- Flood evacuation route signage in place (including Welsh language)

5.4 FLOOD RISK MANAGEMENT CONSIDERATIONS

TAN15 provides a summary of requirements for developments to be considered acceptable. These include the following:

- Flood defences on the site must be regularly checked to ensure that they remain fit for use.
- The site owners should ensure that the defences are maintained in accordance with the manufacturer's instructions.
- The site owner must ensure that current and future occupiers of the development are aware of the flooding risks and consequences.
- Effective flood warnings are provided at the site.
- Escape/evacuation routes are shown by the site owner to be operational under all conditions.
- Flood emergency plans and procedures produced by the site owner must be in place.
- The development is designed by the site owner to allow the occupier the facility for rapid movement of goods/possessions to areas away from floodwaters.
- Development is designed to minimise structural damage during a flooding event and is flood proofed to enable it to be returned to its prime use quickly in the aftermath of the flood.

The above flood risk management measures are required to be introduced in the design, construction, operation and maintenance of the proposed development.

6 ASSESSMENT OF ACCEPTABILITY CRITERIA

6.1 TAN15 – APPENDIX 1

This section of the FCA summaries the details to demonstrate the acceptability of the development with regards the TAN15 section 7 and Appendix 1 Acceptability Criteria requirements.

6.1.1 DEVELOPMENT TYPE

The Development Advice Map (DAM) shows that part of the visitor centre development site is located within Zone A – *“Considered to be at little or no risk of fluvial or tidal/coastal flooding.”* On this basis in accordance with TAN15 a justification test is not applicable and there no need to consider flood risk further for this area.

A portion of the visitor centre development site is located in Flood Zone C2 – *“Areas of the floodplain without significant flood defence infrastructure”*. The results of the updated hydraulic modelling showed that the proposed visitor centre building lies outside of the 1% AEP + 25% climate change allowance floodplain.

Given that the proposed development is vulnerability class fall under “other”, the application of the justification test for this development is not required and this therefore complies with Sections 5, 6 and 7 of TAN15.

6.1.2 FLOOD RESISTANT DESIGN

The developer has considered a number of flood resistant design measures and these include the following:

- Raise the floor level of the building above the 1 in 100 year+25% climate change flood levels
- Ground works will also be designed to prevent capillary action.
- Mechanical and electrical services entering and exiting the building below ground will be designed to prevent damage from flood or ground water.

6.1.3 NO INCREASE IN FLOOD RISK ELSEWHERE

The WSP hydraulic model has demonstrated that there is no increase in fluvial flood risk, flood depth, flow velocity and flood hazard rating upto 1500m downstream of the proposed visitor centre and 600m downstream of the overall DCWW site boundary.

6.1.4 ACCEPTABLE CONSEQUENCES FOR NATURE OF USE

The site is not protected by flood defences and by virtue of its nature, it is required to be associated with the adjacent reservoirs. The model results do not show flooding to the proposed building up to the 1% AEP+25% climate change event. However, a small part of the site outside the proposed visitor centre near the proposed parking area will be flooded with water depths up to 20mm in the 1% AEP climate change event.

The site owner/operator is aware of the residual fluvial flood risk above the design criteria of for this development (1 in 100 year+25% fluvial standard of protection) and the measures required to manage and mitigate against flood risks and the consequences of any flood events to the proposed assets above the design criteria for the lifetime of the development.



6.1.5 AWARENESS OF FLOOD RISK AND FLOOD WARNING SYSTEMS

The developer will be required to provide adequate flood risk information as part of the site management systems to allow safe evacuation of the premises in the event of a flood warning/emergency. A flood action plan would be required in compliance with NRW's requirements.

7 CONCLUSIONS & RECOMMENDATIONS

7.1 CONCLUSIONS

Although the site is partially located in Flood Zone C2, the results of the updated hydraulic modelling showed that the proposed visitor centre building lies outside of the 1% AEP+25% fluvial floodplain. The blockage scenarios undertaken have also shown the building to be unlikely to be affected by the high blockage scenario of the proposed bridge located upstream of the site. The blockage analysis undertaken has shown “Negligible” increase in fluvial flood risk on the development site.

In accordance with Figure 2 of TAN15, this development, by virtue of its nature, is required to be associated with the adjacent reservoirs. Therefore, for the purposes of this FCA, this development is considered to fall under the “other” category of TAN15 and it meets the requirements of Section 5, 6 and 7 of TAN15.

The proposed development involves the redevelopment of previously developed land and there is no increase in the vulnerability class of the development. The hydraulic modelling has shown that the proposed development is unlikely to cause an increase in fluvial flood risk as far as the downstream extent of the WSP model, and although the flood zone is currently given as C2, this development is considered to be appropriate at this location.

The Flood Consequence Assessment has also identified the risk of flooding from the sea, surface water, sewers, highway, canals and groundwater to be between “Negligible” and “Low”.

The risk of reservoir flooding due overtopping or a breach is considered to be between “Low” and “Medium”. As recommended in this FCA, it is essential for flood warning, alerts and evacuations systems are in place in the event of a predicted overtopping or breach of the reservoirs.

Subject to further surveys and finalised agreements with DCWW, NRW and CC’s LLFA, suitable discharge locations are available for the disposal of foul effluent and surface water run-off generated from the proposed development. This will ensure that there is no increase in surface water or foul flood risk elsewhere as a result of the proposed development. The proposed development is not expected to be affected by general objections in respect to draining the site. There will be suitable conditions imposed to ensure that the drainage proposals are designed and constructed in accordance with relevant statutory requirements, including Building Regulations 2010, Sewers for Adoption and the requirements of CC’s surface water management guidance.

7.2 RECOMMENDATIONS

It is recommended that the construction of the proposed access road upgrade to the development is completed ensuring that there is adequate provision for the management of surface water from the road within the proposal to prevent highway flooding.

Further long term testing/monitoring is recommended to be undertaken of the groundwater movement to ascertain any residual risk and inform any mitigation measures required.

It is also recommended that the minimum threshold levels are set at or above 45.10mAOD to reduce future risk of fluvial flooding from the Nant Fawr for the agreed design standard of protection (of 1 in 100+25% climate change).



It is also recommended to ensure that, as part of the site maintenance, the local hydraulic structures along the Nant Fawr, e.g. bridges and culverts are kept clear of debris and blockages to reduce the risk of fluvial flooding.



Appendix A

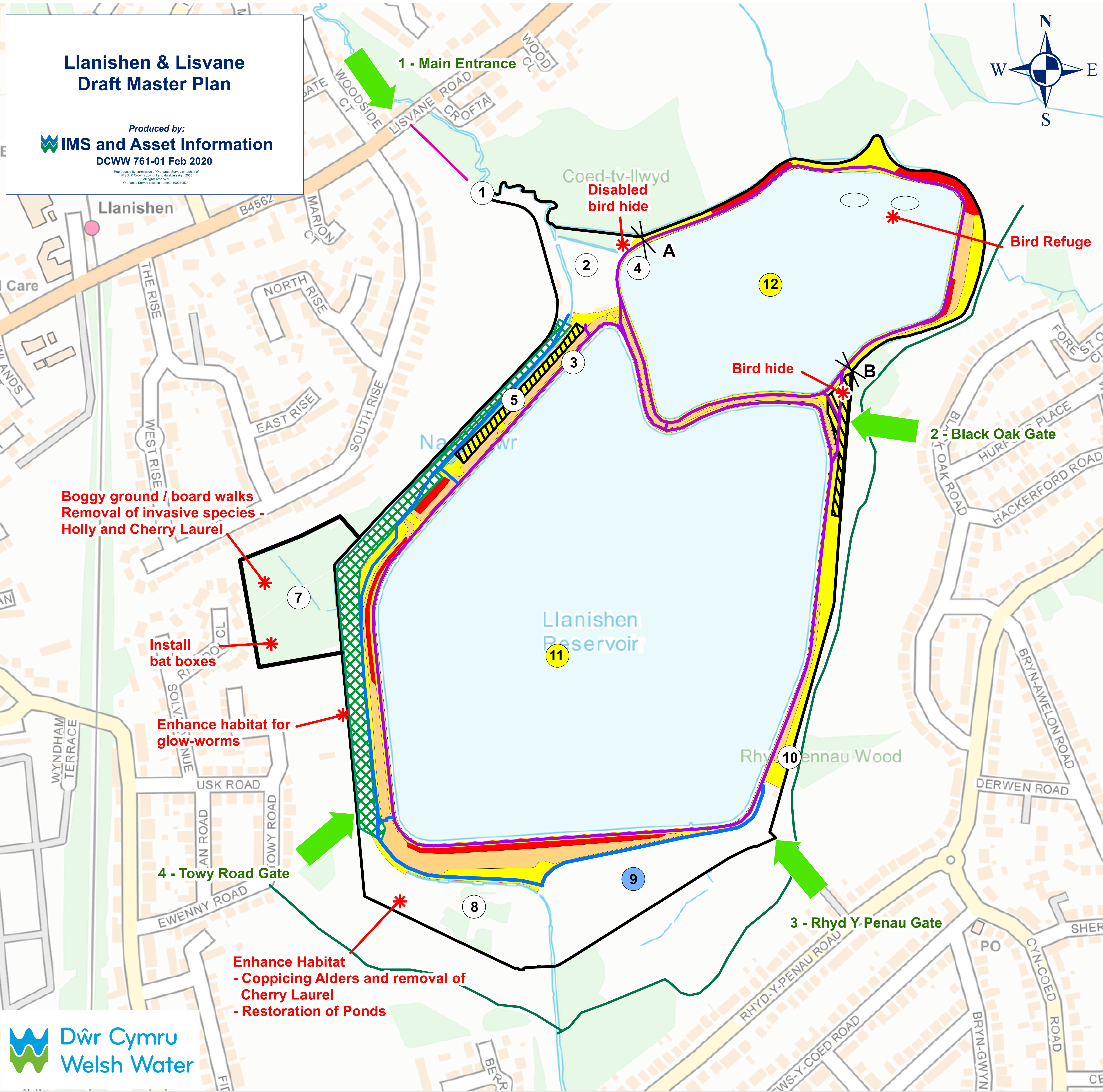
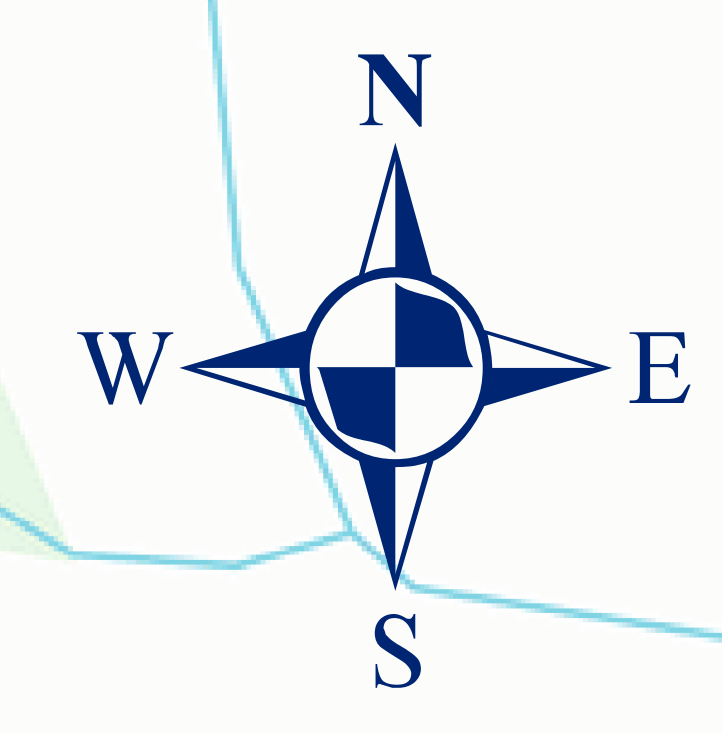
DEVELOPMENT PLAN



Llanishen & Lisvane Draft Master Plan

Produced by:
IMS and Asset Information
 DCWW 761-01 Feb 2020

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- DCWW Boundary
- Upper Footpath
- Lower Footpath
- National Cycle Track
- Amenity Grass
- Pollinators and Wildflower Fringe
- Priority areas with high fungi/plant diversity
- Priority areas with medium fungi/plant diversity
- SSSI

Proposals

- ① Access Road upgrade
- ② Car Park and Visitor Centre
- ③ Slipway and Floating Pontoon
- ④ Water access pontoon
- ⑤ Picnic Area
- ⑦ Gwerny-Bendy-Wood Conservation Zone
- ⑧ Education Zone
- ⑩ Viewpoint/Rest point
- ✕ Lisvane Gates - Winter No Entry

- 1 - Main Entrance
- 2 - Black Oak Gate
- 3 - Towy Road Gate
- 4 - Rhyd Y Penau Gate

Under Consideration

- ⑨ Recreation Zone

Other

- ⑪ Llanishen - Water Sports
- ⑫ Lisvane - Winter Conservation

Boggy ground / board walks
Removal of invasive species - Holly and Cherry Laurel

Install bat boxes

Enhance habitat for glow-worms

4 - Towy Road Gate

Enhance Habitat
 - Coppicing Alders and removal of Cherry Laurel
 - Restoration of Ponds

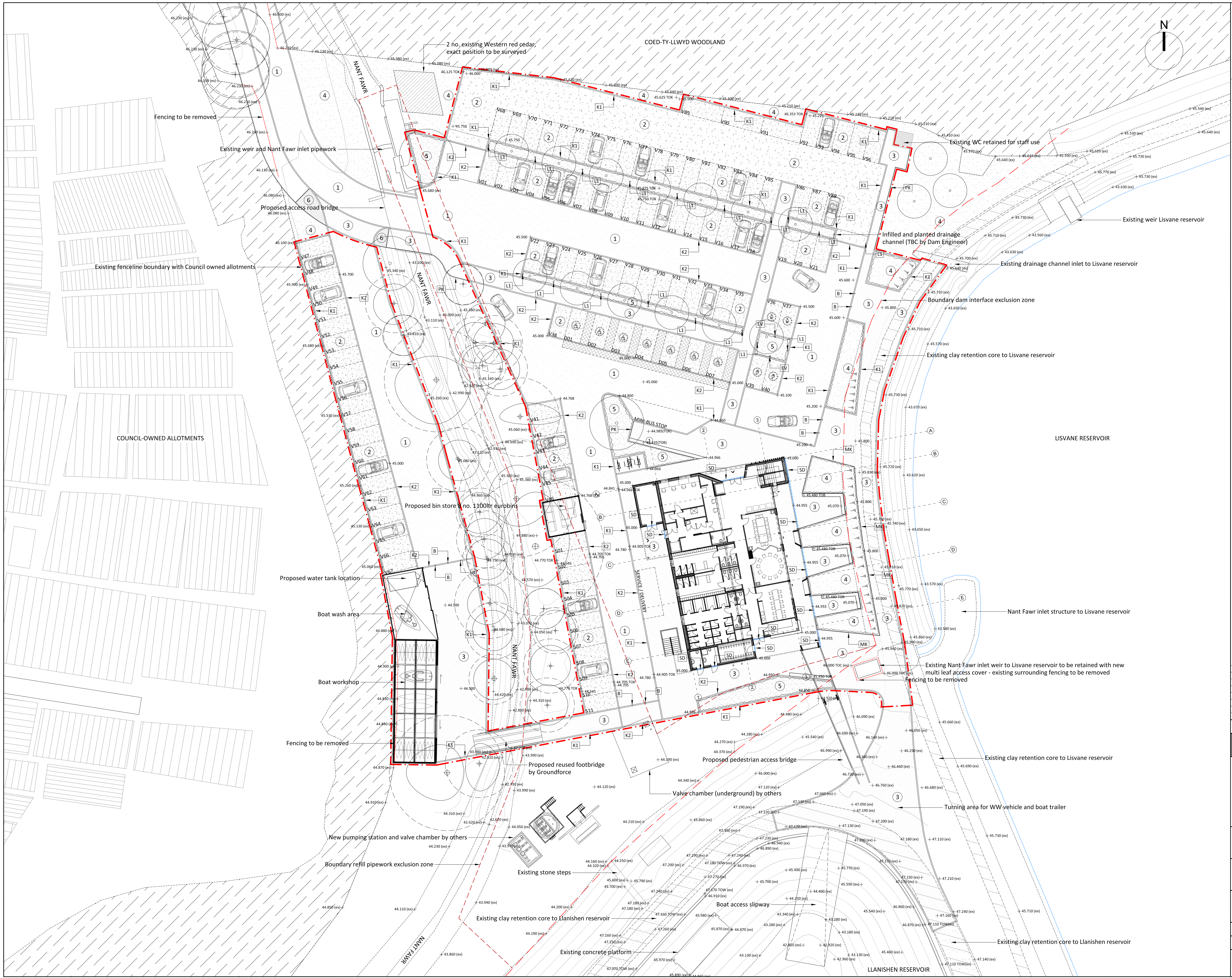
Disabled bird hide

Bird hide

Bird Refuge

2 - Black Oak Gate

3 - Rhyd Y Penau Gate



GENERAL NOTES:

1. ALL DIMENSIONS AND LEVELS SHALL BE CHECKED ON SITE PRIOR TO CONSTRUCTION WORKS COMMENCING.
2. ALL LANDSCAPE DRAWINGS TO BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECTS & ENGINEERS DRAWINGS AND SPECIFICATIONS.
3. ANY DISCREPANCY CONCERNING THE DRAWINGS SHOULD BE REFERRED TO LANDSCAPE ARCHITECT IMMEDIATELY.
4. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS NOTED OTHERWISE.
5. ALL LEVELS ARE IN METERS.
6. EXISTING SERVICE ALIGNMENTS SHALL BE CHECKED ON SITE BY THE CONTRACTOR PRIOR TO CONSTRUCTION WORK COMMENCING.

Key

- Site boundary
- Existing trees retained with root protection area as shown
- Proposed semi-mature trees
- Tarmac road surface
- Cell web-crate system with gravel infill
- Resin-bound aggregate
- Grass and willow/meadow seeding
- Proposed herbaceous planting areas
- Tactile paving
- Proposed concrete benches
- Existing/proposed retaining walls
- Existing boundary fence/Existing fence to be removed
- Existing coniferous woodland to be retained
- Existing woodland and dense vegetation adjacent to Welsh water boundaries
- Gravel paths along reservoir edges
- Reservoir clay retention core outline
- Dam interface/Refill pipework exclusion zones
- S/V/D01 Proposed parking bays (S=Staff, V=Visitor, D=Disabled)
- K1 Concrete conservation kerb 915(1)x145(w)x255(d)mm - raised kerb laid upright - by Marshalls or similar & approved
- K2 Concrete conservation kerb 915(1)x145(w)x255(d)mm - kerb laid flush - by Marshalls or similar & approved
- PK Concrete pin kerb 914(1)x63(w)x150(d)mm laid upright by Marshalls or similar & approved
- MK Mild steel metal edging 10(w)x200(h)mm
- LI Lighting columns
- EV Electric vehicle charging point
- B Removable vehicle bollard
- BT Bib tap locations
- SD Proposed slot drains
- +99.820 (ex) / +99.800 Existing levels / Proposed levels

Rev	Date	Description	Drawn	Checked
A	21.06.19	Steps to Reservoir embankment removed	CG	MND

FOR PLANNING

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 E contactus@lstudio.co.uk

Client: **DWR CYMRU WELSH WATER**

Project: **LISVANE & LLANISHEN VISITOR CENTRE**

Title: **LANDSCAPE GENERAL ARRANGEMENT**

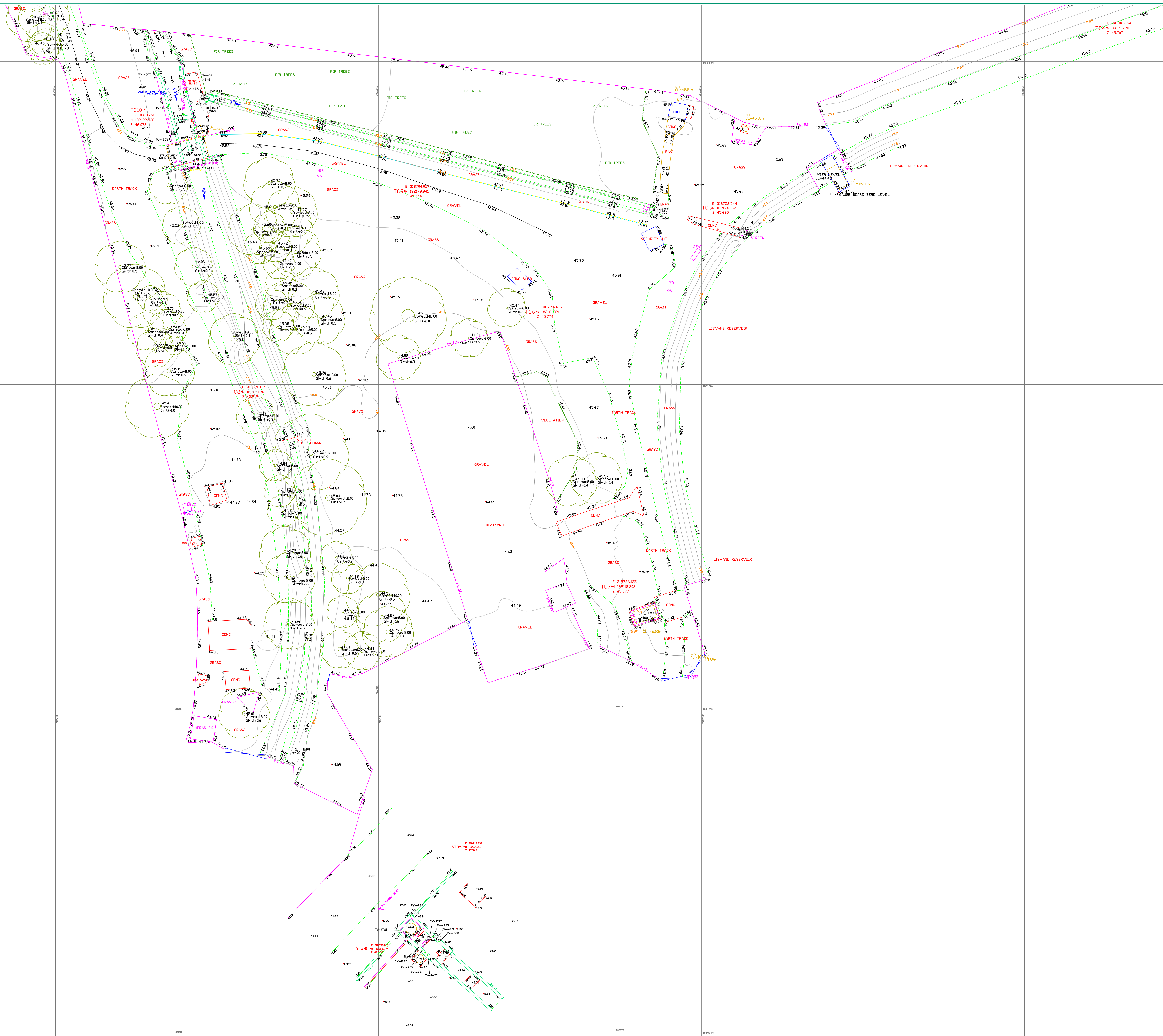
Designed: MND Drawn: CG Checked: NJR
 Scale @ A1: 1:250 Date: MAR 2019 Approved: MND
 Drawing No.: LTS_099(08)101 Revision: A



Appendix B

TOPOGRAPHIC SURVEY





Rev	Amendments	Date	By

NOTES:
 1. SITE GRID AND LEVELS ARE BASED UPON ORDNANCE SURVEY VIA THE ACTIVE OPS NETWORK.

Do not scale this drawing

This drawing is copyright.

KEY

TSB	TRAFFIC SIGNAL BOX
PSB	PHONE BOX
PS	POST BOX SQUARE
PSR	POST BOX ROUND
OSQ	ORILL SQUARE
ORR	ORILL ROUND
BS	BOLLARD
BSR	BIN SQUARE
BSR	BIN ROUND
SP	SPOT LEVEL
TAR	TAR
GR	GRASS
HVS	HARDSTANDING
BL	BOLLARD
BS	BEACON
RS	ROAD SIGN
SSN	SIGN
SNP	STREET NAMEPLATE
TS	TRAFFIC SIGNAL
TSC	TRAFFIC SIGNAL CONTROLLER
IC	INSPECTION COVER
MH	MANHOLE
MHP	MANHOLE POST
TP	TELEGRAPH POLE
LC	LIGHTING COLUMN
Q	QUALITY
VM	WATER METER
SV	SURFACE VALVE
ST	STOP TAP
FW	FIRE HYDRANT
BT	BRITISH TELECOM
CATV	CABLE TV
TV	CABLE TV
GV	GAS VALVE
BRW	BRICK WALL
BLW	BLOCK WALL
STW	STONE WALL
HC	HEDGEROW/TREE CANOPY
22 F/W	FENCE
DK	DROPPED KERB

Alpine Land Surveyors Ltd
 Tower Business Centre, Hinxton
 Industrial Estate, Hinxton,
 Aberdeenshire, CF44 6LP
 Tel/Fax: 01685 814544 Mobile:
 07980 404 208
 j.price@alpineandsurveyors.co.uk

CLIENT
 LEWIS CIVIL
 ENGINEERING

PROJECT
 TOPOGRAPHICAL SURVEY
 LLANISHEN/LISVANE
 RESERVOIRS, CARDIFF.

Scale: 1:200@A0	Date: 09.10.17
Drawn: TJC	Checked: AJ
Project Reference No: ALS/01482	
Drawing Number: LEW/LISH/003	

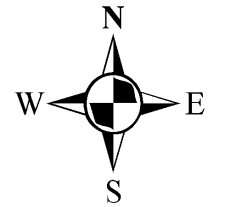


Appendix C

DCWW SEWER RECORDS



--- Enter drawing title here ---



LEGEND (Representative of most common features)

	Gravity Sewer
	Sluice Valve
	Rising Main
	Air Valve SINGLE
	Outfall
	Tap
	Pumping Station
	Pressure Reducing Valve
	Lamphole
	Meter
	Combined Sewer Overflow
	Special Purpose Chamber
	Bulk Meter
	Treatment Works
	Fire Hydrant
	Private Sewer Transfer
	Cap
	Non Dwr Cymru Main
	Existing Distribution Main
	Lateral Drain
	Inspection Chamber

NB: Sewer symbol colour indicates the sewer type.
RED - Combined
GREEN - Surface Water
BROWN - Foul

Notes:
--- Type notes here ---
--- Remembering to manually add line breaks ---

Whilst every reasonable effort has been taken to correctly record the pipe material of DCWW assets there is a possibility that in some cases pipe material (other than Asbestos Cement or Pitch Fibre) may be found to be asbestos cement (AC) or Pitch Fibre (PF). It is therefore advisable that the possible presence of AC or PF pipes be anticipated and considered as part of any risk assessment prior to excavation.

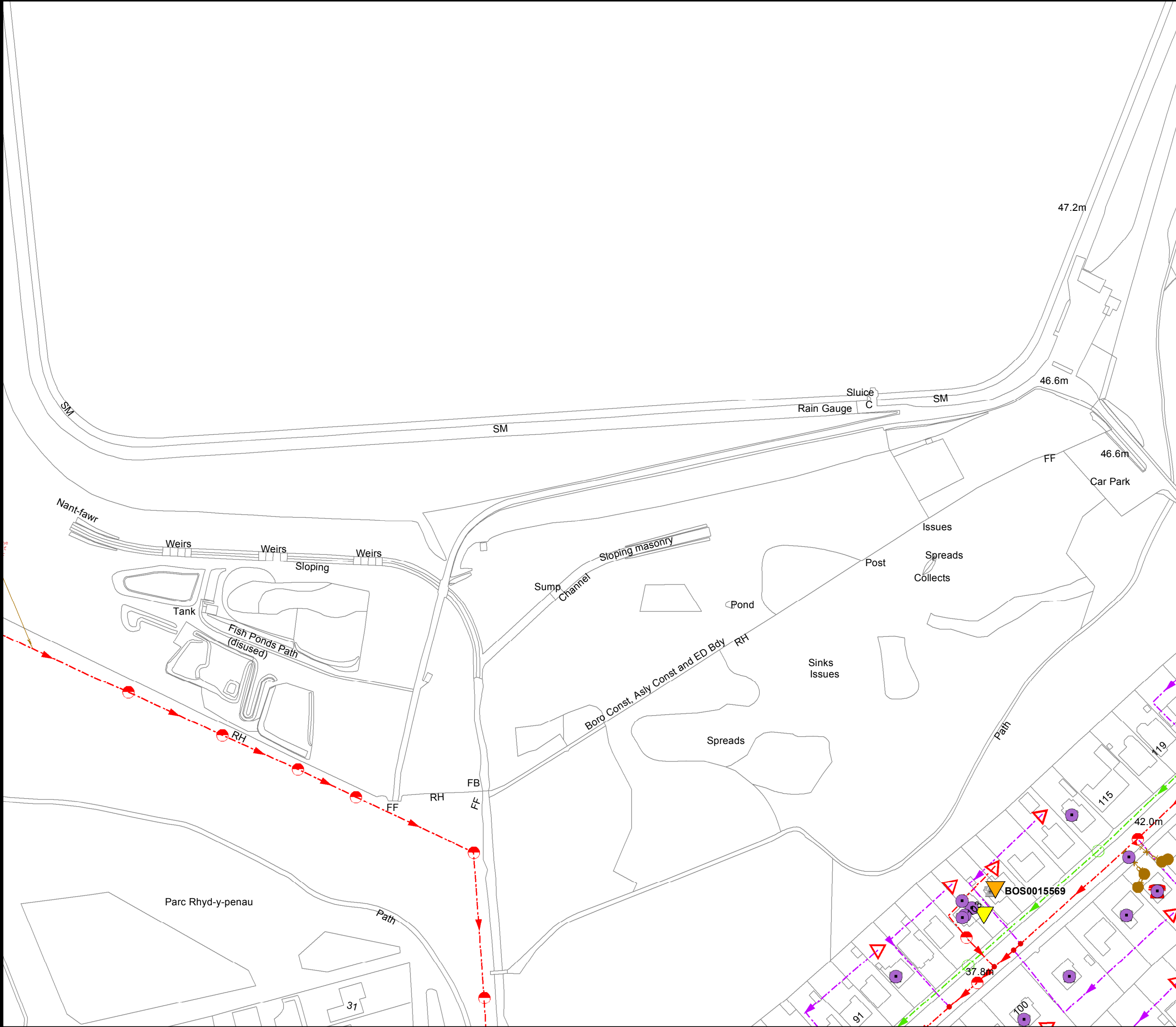
Dwr Cymru Cyf gives this information as to the position of its underground apparatus by way of general guidance only on the strict understanding that it is based on the best information available and no warranty as to its correctness is relied upon in the event of excavations or other works made in the vicinity of the Company's apparatus and any onus of locating the apparatus before carrying out any excavations rests entirely on you. It must be understood that the furnishing of the information is entirely without prejudice to the provision of the New Roads and Streetworks Act 1991 and of the Company's right to be compensated for any damage to its apparatus.

Service pipes are not generally shown but their presence should be anticipated.

EXACT LOCATIONS OF ALL APPARATUS TO BE DETERMINED ON SITE.

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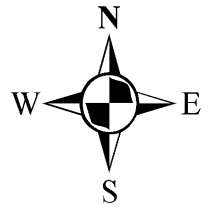
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Map scale: 1:1,500
Printed by:
Printed on: 08/02/2017





Dŵr Cymru
Welsh Water

--- Enter drawing title here ---



LEGEND (Representative of most common features)

- Sluice Valve
 - Air Valve SINGLE
 - Tap
 - Pressure Reducing Valve
 - Meter
 - Bulk Meter
 - Fire Hydrant
 - Cap
 - Non Dwr Cymru Main
 - Existing Distribution Main
 - Gravity Sewer
 - Rising Main
 - Outfall
 - Pumping Station
 - Lamphole
 - Combined Sewer Overflow
 - Special Purpose Chamber
 - Treatment Works
 - Private Sewer Transfer
 - Lateral Drain
 - Inspection Chamber
- NB: Sewer symbol colour indicates the sewer type.
 RED - Combined
 GREEN - Surface Water
 BROWN - Foul

Notes:

--- Type notes here ---
--- Remembering to manually add line breaks ---

Whilst every reasonable effort has been taken to correctly record the pipe material of DCWW assets there is a possibility that in some cases pipe material (other than Asbestos Cement or Pitch Fibre) may be found to be asbestos cement (AC) or Pitch Fibre (PF). It is therefore advisable that the possible presence of AC or PF pipes be anticipated and considered as part of any risk assessment prior to excavation.

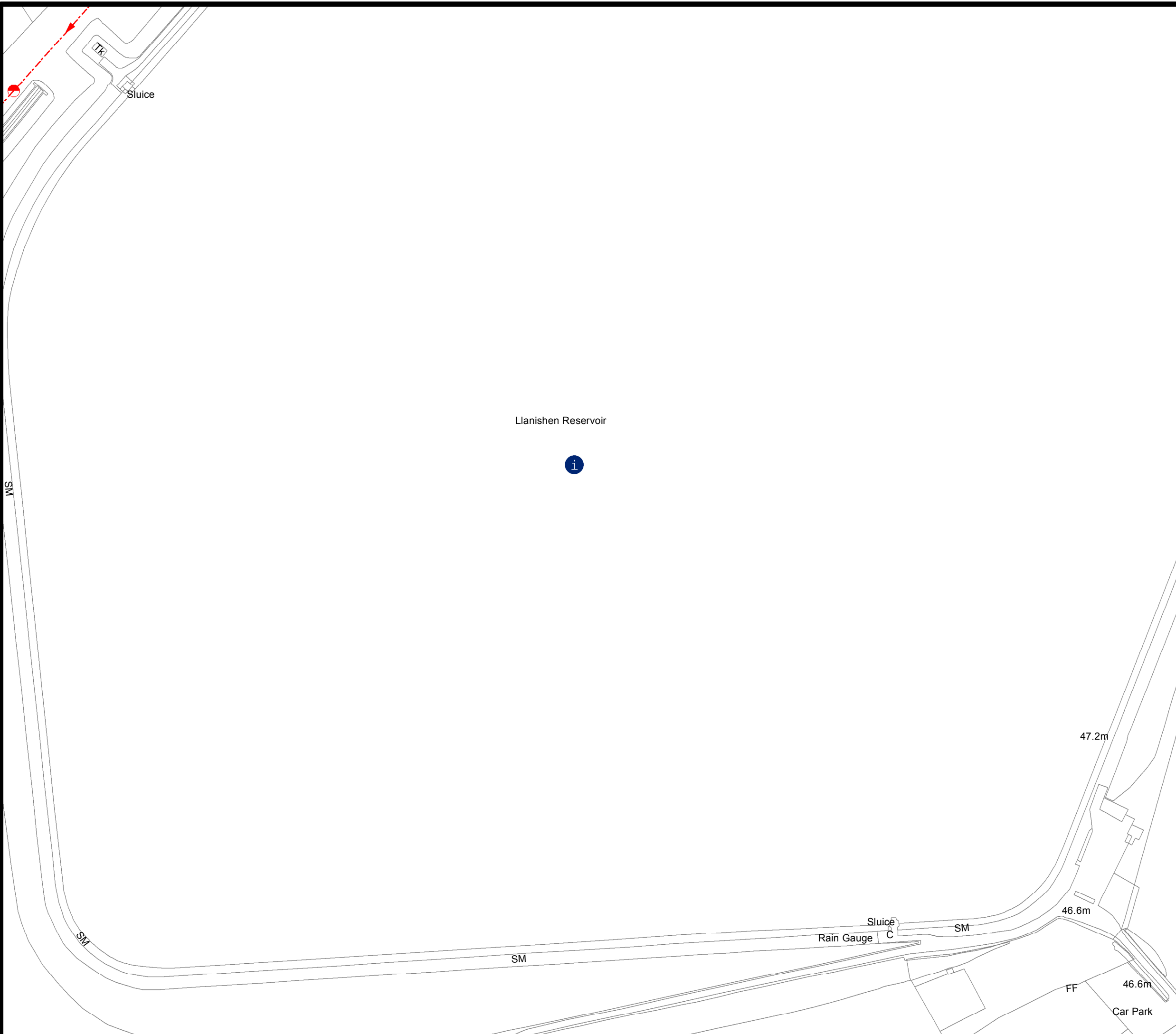
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Service pipes are not generally shown but their presence should be anticipated.

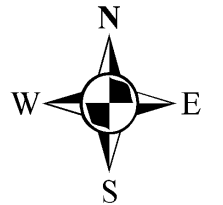
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Printed on: 08/02/2017



--- Enter drawing title here ---



LEGEND (Representative of most common features)

Gravity Sewer	Rising Main
Sluice Valve	Outfall
Air Valve SINGLE	Pumping Station
Tap	Lamphole
Pressure Reducing Valve	Combined Sewer Overflow
Meter	Special Purpose Chamber
Bulk Meter	Treatment Works
Fire Hydrant	Private Sewer Transfer
Cap	Lateral Drain
Non Dwr Cymru	Inspection Chamber
Existing Distribution Main	

NB: Sewer symbol colour indicates the sewer type.
RED - Combined
GREEN - Surface Water
BROWN - Foul

Notes:

- Type notes here ---
- Remembering to manually add line breaks ---

Whilst every reasonable effort has been taken to correctly record the pipe material of DCWW assets there is a possibility that in some cases pipe material (other than Asbestos Cement or Pitch Fibre) may be found to be asbestos cement (AC) or Pitch Fibre (PF). It is therefore advisable that the possible presence of AC or PF pipes be anticipated and considered as part of any risk assessment prior to excavation

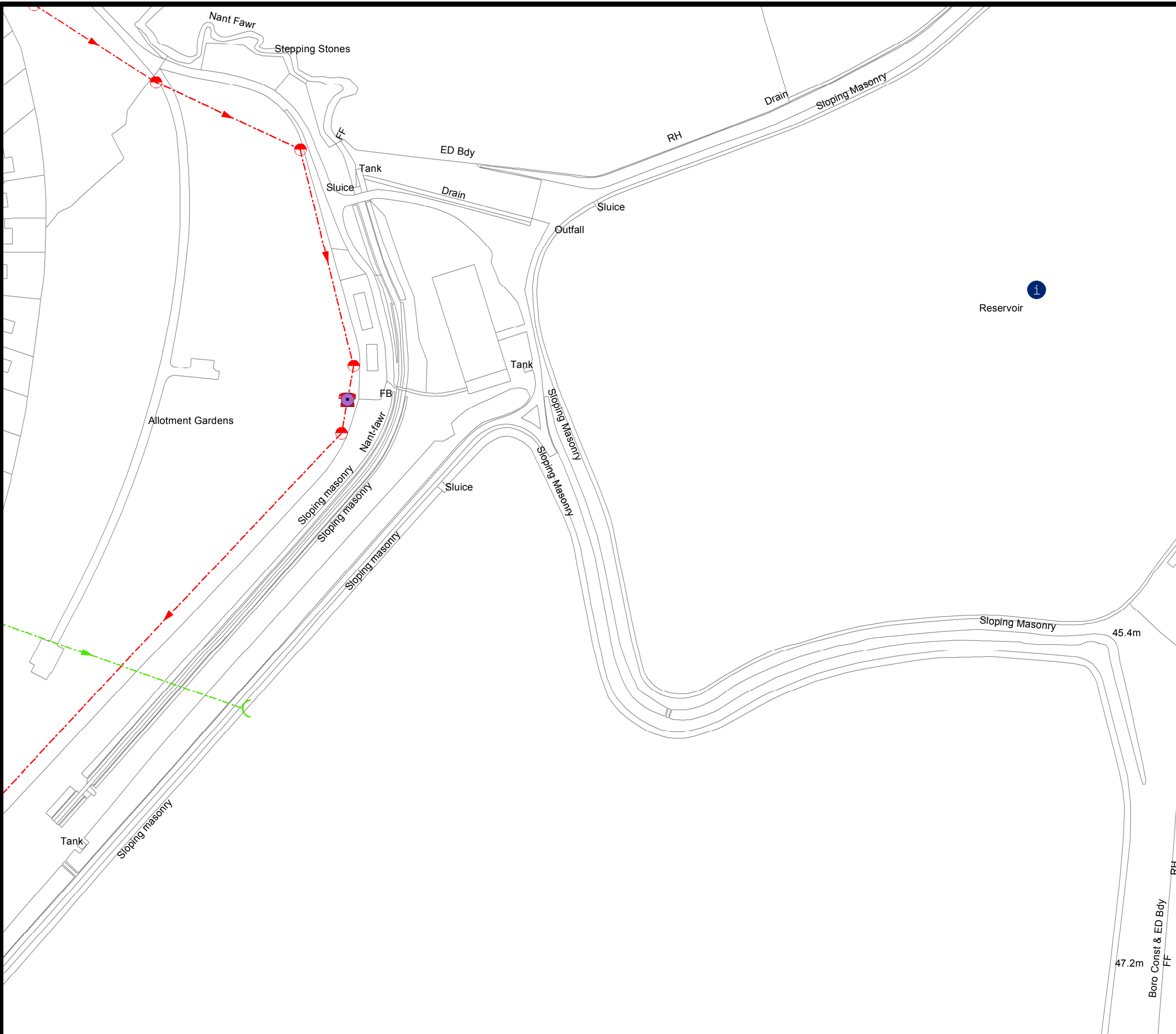
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Service pipes are not generally shown but their presence should be anticipated.

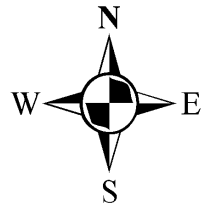
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--- Enter drawing title here ---



LEGEND (Representative of most common features)

Gravity Sewer	Rising Main
Sluice Valve	Outfall
Air Valve SINGLE	Pumping Station
Tap	Lamphole
Pressure Reducing Valve	Combined Sewer Overflow
Meter	Special Purpose Chamber
Bulk Meter	Treatment Works
Fire Hydrant	Private Sewer Transfer
Cap	Lateral Drain
Non Dwr Cymru	Inspection Chamber
Existing Distribution Main	

NB: Sewer symbol colour indicates the sewer type.
RED - Combined
GREEN - Surface Water
BROWN - Foul

Notes:

--- Type notes here ---
--- Remembering to manually add line breaks ---

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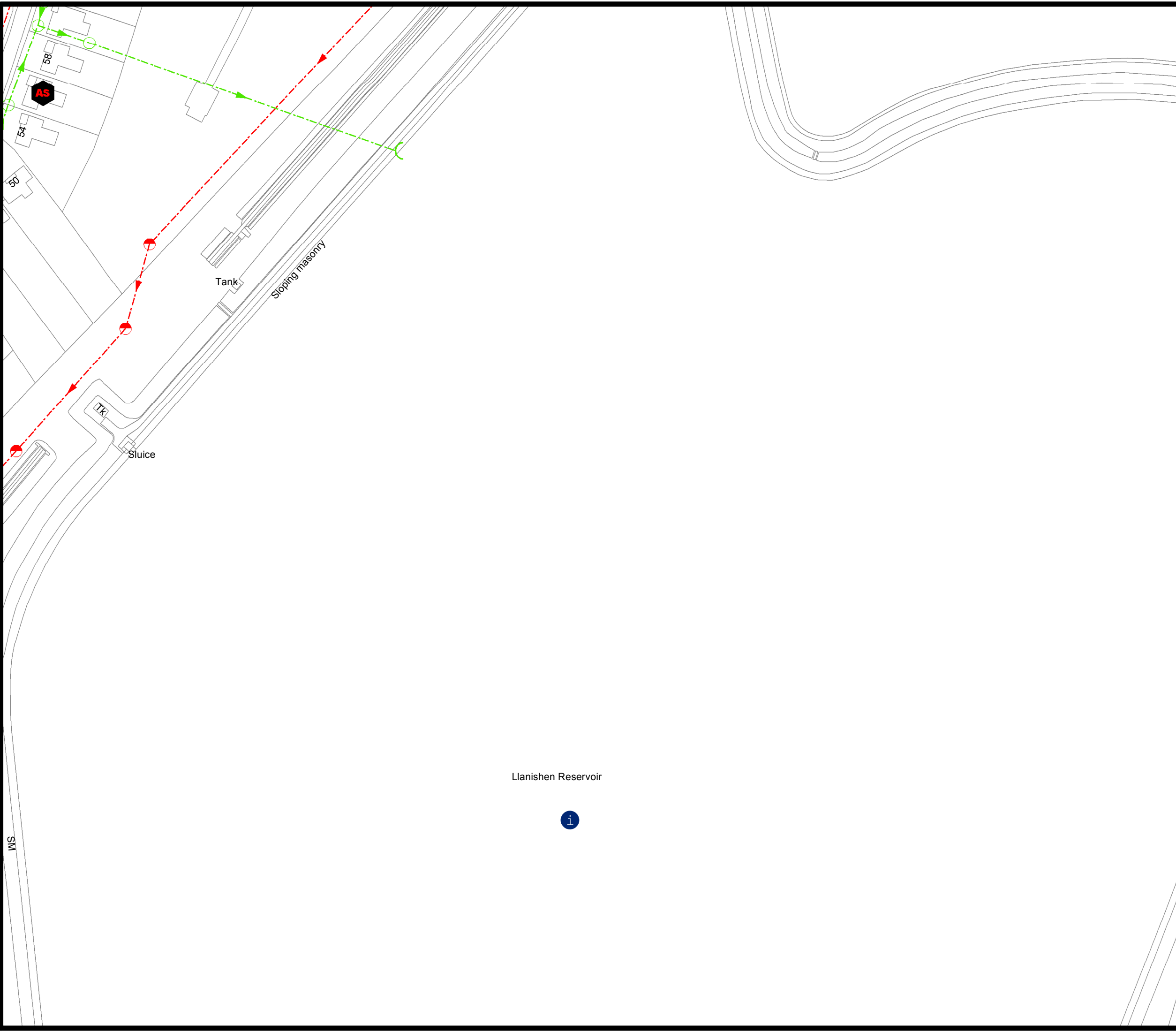
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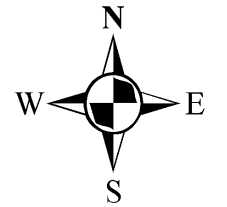


Llanishen Reservoir
























SM

--- Enter drawing title here ---



LEGEND (Representative of most common features)

	Gravity Sewer
	Sluice Valve
	Rising Main
	Air Valve SINGLE
	Outfall
	Tap
	Pumping Station
	Pressure Reducing Valve
	Lamp Hole
	Meter
	Combined Sewer Overflow
	Bulk Meter
	Special Purpose Chamber
	Fire Hydrant
	Treatment Works
	Cap
	Non Dwr Cymru Main
	Existing Distribution Main
	Private Sewer Transfer
	Lateral Drain
	Inspection Chamber

NB: Sewer symbol colour indicates the sewer type.
RED - Combined
GREEN - Surface Water
BROWN - Foul

Notes:

--- Type notes here ---
--- Remembering to manually add line breaks ---

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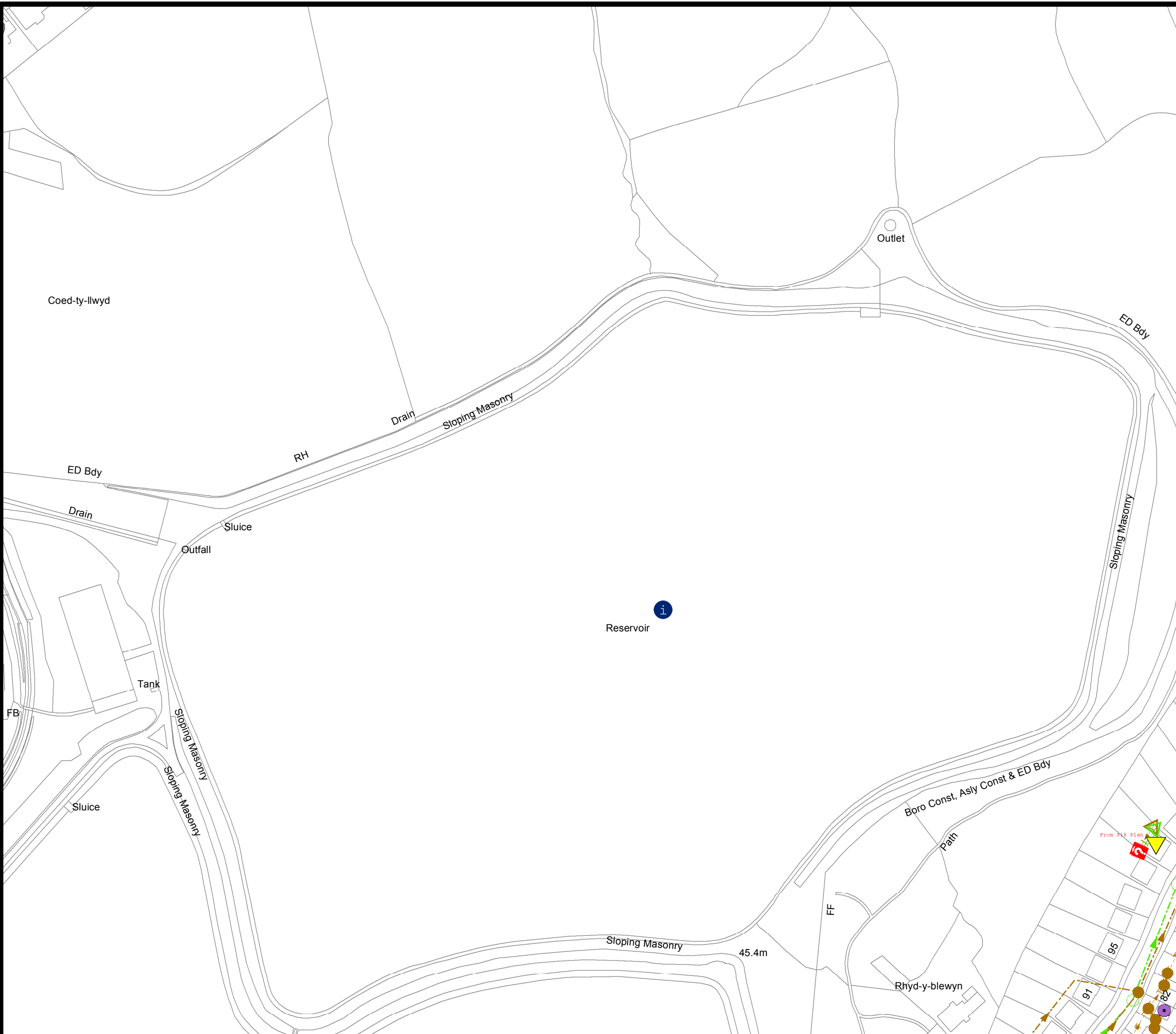
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Appendix D

HYDRAULIC MODELLING REPORT

Refer to WSP Report ref: 70062284/MOD/01, July 2020





Opus House
Yale Business Village
Wrexham Technology Park
Wrexham

wsp.com