Llywodraeth Cymru
Welsh Government

A55(T) Chester to Bangor Trunk Road: Abergwyngregyn to Tai'r Meibion Improvement

ENVIRONMENTAL STATEMENT
VOLUME 2: TECHNICAL APPENDIX D
ROAD DRAINAGE AND THE WATER ENVIRONMENT

YGC

This Technical Appendix contains the following documents, which support Chapter 5.10 (Road Drainage and Water Environment) of the Environmental Statement:

- A55(T) Abergwyngregyn to Tai'r Meibion Flood Consequence Assessment (YGC, 2016)
- A55(T) Abergwyngregyn to Tai'r Meibion Erosion Protection and Sediment Control Plan (YGC, 2016)
- A55(T) Abergwyngregyn to Tai'r Meibion WFD Initial Compliance Assessment (YGC, 2016)
- A55(T) Abergwyngregyn to Tai'r Meibion Drainage Strategy Report (YGC, 2016)
- A55(T) Abergwyngregyn to Tai'r Meibion Drainage Strategy Drawings (YGC, 2016)
- A55(T) Abergwyngregyn to Tai'r Meibion typical edge of carriageway drainage bund detail (YGC, 2016)
- A55(T) Abergwyngregyn to Tai'r Meibion Existing Drainage Survey Report (YGC, 2016)

A55(T) ABERGWYNGREGYN - TAI'R MEIBION IMPROVEMENT

FLOOD CONSEQUENCE ASSESSMENT (FCA)

CPF 5055
Welsh Government

Document Control Sheet

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Revision History

Date	Version No.	Summary of Changes
	0.01	
12/07/2016	0.02	Comments from NRW regarding model, Updated model to include mitigation
24/10/2016	0.03	Comments from Welsh Government

Approvals

Approved by	Signature	Date	Version
Rob Williams		**24/10/ 16**	**0.03**

Distribution

Name	Title	Date	Version

ISO9001:2008 FS526386 | ISO14001:2004 EMS 526388 | OHSAS18001:2007 OHS 526389

Contents

Executive Summary

This report outlines the flood risk of a section of the A55(T) between Abergwyngregyn and Tai'r Meibion, which is proposed for upgrading to meet current safety standards. The report outlines current sources of flooding; evaluates the potential flooding from the Proposed Improvement and provides suggestions for flood mitigation and alleviation.

The A55(T) is the major road into North Wales and connects the mainland UK to Ireland. The road is key for transportation of goods and is the major route for travellers to and from North Wales. The section from Abergwyngregyn to Tai'r Meibion is now almost 40 years old, and, although originally constructed to current standards, no longer meets the new road safety standards. The forward visibility of the road is significantly impaired for a road with fast traveling vehicles. The crossings from farm buildings, fields and houses also impedes traffic flow and is a significant hazard as these crossings are often used by slow moving vehicles. There have been past instances of flooding along this section of the A55(T) which has led to lane closure and in more than once instance, complete closure of the entire road.

The A55(T) Improvement scheme (hereafter referred to as the Proposed Improvement) looks to not only improve road safety and standards but also to alleviate flooding to the A55(T). Lane closure, or indeed entire road closure, is of huge detriment to goods vehicles and visitors/ residents travelling to and from the area.

The Proposed Improvement will include closure of all the road crossings, incorporating a new country road/PMA/NMU which will join the A55(T) via the slip road at Abergwyngregyn (Junction 13) and connect to the Tal y Bont interchange at Junction 12. The road design will also include new and updated drainage which will be more efficient and effective at removing surface water from the road surface combined with better filter and pollution control measures.

The Proposed Improvement will allow for improved safety and continued economic growth.

Existing Flood Risk Information

Requests for data and information in relation to flooding along the Proposed Improvement were sent to:

- Natural Resources Wales (NRW)
- Gwynedd Council (GC)
- North and Mid Wales Trunk Road Agency (NMWTRA)

Available information provided included:

- Flood maps
- TAN15 Development Advice Maps
- Flood Map for Surface Water
- Floodplains

There were no existing hydraulic models of the relevant watercourse catchments suitable to inform flood consequence assessment.

Gwynedd Council have provided information on known flood history as well as plans of the culverts along the Proposed Improvement.

NWMTRA provided detailed information of the causes and extent of flooding events.

Flooding records have indicated that the Proposed Improvement has historic flood risk issues with surface water and hydraulic overloading of the current road drainage system combined with runoff from the surrounding fields.

Baseline Flood Risk

The Development Advice Map which supports TAN15 suggests that there are no areas within the Proposed Improvement area at risk from fluvial or tidal flooding. The flood maps illustrate that the Proposed Improvement area is at risk of surface water flooding.

New hydrological and hydraulic models have been developed to assess the flood risk along Stream 5 (Afon Wig). Hydraulic modelling for Stream 5 has been developed to establish the flood risk to the Wig Crossing Cottages and the proposed development from increased culvert size under the Proposed Improvement.

There is no evidence to suggest that the area is at risk from groundwater flooding.

With Scheme Flood Risk

Works will be undertaken to ensure that the Proposed Improvement will remain flood free for the 1 in 100 year event (1% annual chance event (AEP)) including a 30% allowance for climate change.

The main sources of flood risk to the Proposed Improvement are:

- Surface runoff

- Hydraulic overload of drainage systems
- Runoff from surrounding fields

Without mitigation the proposed development would potentially have an adverse effect on flooding to the Wig Crossing Cottages downstream of Stream 5 (Afon Wig) during the 1 in 1000 year event (0.1% AEP) and the 1 in 100yr +CC (1% AEP +CC) event with the incorporation of specific mitigation measures. Hydraulic modelling will illustrate the flood risk posed by this location pre and post scheme.

Proposed Mitigation Measures

A detention pond at the site of Wig Bach to hold increased water during times of increased rainfall would slow the rate of water being discharged to the area to greenfield rates. The pond will also act as a pollution control measure for settling sediment and removal of pollutants from the water before it is discharged into the streams.

To ensure protection to Wig Crossing Cottages, mitigation will be provided in the form of a wall to protect from fluvial flooding from the Afon Wig (stream 5) following the upsizing of the upstream culvert. The wall will ensure that Wig Crossing Cottages will remain flood free up to the 1 in 1000 year +CC (0.1% AEP) event. This has been illustrated using hydraulic modelling. The final location and height of the boundary wall will be determined at the detailed design stage. The levels of the wall are outlined in the Wig Mitigation Drawings in Appendix Z

However, following concerns raised by NRW and the residents of Wig Crossing Cottages in relation to the potential for surface water to pool behind the proposed wall, further drainage will be incorporated into the Proposed Improvement at this location to ensure that Wig Crossing Cottages are not at increased risk of surface water flooding.

Using methodology and guidance outlined in the SuDS manual (CIRIA C753) an assessment of the greenfield runoff from the catchment area has been carried out. The use of the revitalised Flood Hydrograph Model (ReFH2) methodology with the use of the Plot Scale option enabled, allowed efficient adjustment of the catchment area and the relevant catchment descriptors allowed a realistic estimate of the greenfield runoff. The initial catchment area was derived using LiDAR data provided by Welsh Government. The watershed analysis was then carried out in GIS software to derive the specific catchment areas using a specific outfall location. Following both assessments, using the tables produced by HR Wallingford for the size of culverts in relation to runoff rates, the size of the culverts has been calculated. Therefore an additional outfall from the railway embankment of a minimum 300mm diameter, to remove surface water will be provided; along with

a minimum 300mm diameter pipe incorporated within the surface water drainage to the south of Wig Crossing Cottages draining into the Afon Wig (Stream 5) from the Wig Crossing Cottages access track.

The increased outfalls and drainage of surface water will ensure that Wig Crossing Cottages will not be at increased risk of surface water pooling behind the proposed mitigation wall.

Other watercourses, streams and ditches

All new or upgraded culverts, together with existing culverts which are to be retained, have been assessed to ensure that they will either convey a 1 in 100 year event (1% AEP) flow including 30% allowance for climate change, or that they will not impact on flood risk within the locality.

Runoff from the Scheme

The drainage from the Proposed Improvement is to be updated and redesigned with increased culvert capacity in areas, detention pond and filter drains. Designs will be such that peak discharge including allowance for climate change will be restricted to a third of the pre improvement runoff rates.

Groundwater Flooding

No locations of groundwater flooding have been identified. Based on the topography of the area, it is considered unlikely that groundwater flooding will be a significant risk to the Proposed Improvement. The management of groundwater is not considered to be an issue and will be controlled through geotechnical design.

Bund / cut off channel

To the south of the A55(T) a new bund and cut off channel will be constructed to provide the main mitigation from the fields to the south of the Proposed Improvement. The bund will extend from the upstream of Stream 4 running to beyond the upstream of Stream 8. The bund will be designed to hold excess water back from the A55(T) using a cut off channel to allow the excess water to enter the drainage system to be discharged into the streams.

Summary

It is considered that the sources of flood risk associated with the Proposed Improvement are understood. These risks can be mitigated through the Proposed Improvement's design. This will ensure that the Proposed Improvement will remain flood free for a 1 in 100 year event (1% AEP) including an allowance of +30% for climate change. The Proposed Improvement is also considered to

remain flood free for more extreme events up to 1 in 1000 year event (0.1% AEP) but will increase flood depths within the floodplain by up to 0.20m and around Wig Crossing Cottages by up to 0.05m. This can be achieved without causing any adverse impacts on flood risk elsewhere within the locality. Specifically the Proposed Improvements to the drainage system and watercourse capacity including the new bund and cut-off channel are aimed at reducing the risk of flooding to:

- Wig Crossing Cottages and its access road
- The carriageway at flooding hotspots between Junction 12 and 13; specifically between Ty'n yr Hendre junction (Stream 1) and Stream 2. This area is known to have been severely flooded in the past five years (worst flood events seen in 2012 and 2015) resulting in partial or full road closure for up to 12 hours.

Section 3.6 Flood History outlines the known flood history to this section of the A55.

1.0 The Project

1.1 Context

The Welsh Government have commissioned YGC to carry out a re-design to improve a 2.2 km section of the A55(T) from Abergwyngregyn to Tai'r Meibion as the section of the A55(T) is no longer compliant with current standards. Through improving the road safety, additional drainage of the section will be included, combined with updating and improving current drainage. With improved drainage from the A55(T), the surrounding land may be a recipient of increases in water.

This section of the A55(T) is now over 38 years old and the vertical alignment, although originally designed to standards current at the time, does not comply with the present-day standards to which the adjacent sections have been built. The current forward visibility distances are significantly below existing requirements and the Proposed Improvement would aim to address this deficiency. The latest standards also require 1m wide hard strips on each side of both carriageways.

The central reservation gaps, private entrances, field accesses and junction to the Class 3 County Road are often used by slow-moving vehicles, which is a detriment to the free and safe flow of through traffic on the A55(T).

After many years of routine and structural maintenance involving surface treatment, the road pavement has reached the end of its useful life and it is therefore necessary, as a minimum, to overlay the existing pavement with new bituminous material.

Following heavy storms in recent years flooding has occurred, particularly at the west end of the Proposed Improvement, which has resulted in the closure of one or both carriageways. Improvements to the drainage system are therefore required to alleviate this problem in the future. Culverts also act as discharge points for the surface water drainage from the main carriageway and improvements are required to drain this water effectively. Increased attenuation will be incorporated into the updated drainage design.

1.2 Background

The A55(T) dual carriageway is a key transport link to North Wales and Ireland. Recent flood events have resulted in partial lane closure and full closure of the road. This has resulted in economic loss and disruption to the local and commuting traffic. Improvement is necessary to ensure that safe and easy travel between mainland UK and Ireland continues. The overall objective of the scheme is to improve safety standards of the A55(T), rather than increase the capacity of the existing carriageway for increased traffic flow

1.3 The Scheme

The improvement will run from Abergwyngregyn along the A55(T) for approximately 2.2km to Tai'r Meibion. The Proposed Improvement will include improved safety and drainage of this section of the A55(T). Through realignment, widening and increased drainage ability the section will conform to modern standards. See Appendix B for location and extent of the Proposed Improvement works.

The proposed drainage design extends over a length of approximately 3.2km from the Tal y Bont interchange (Junction 12) to the stream adjacent to Pentre Aber Farm (in order to cater for the new county road and NMU route to the north of the A55(T) in addition to the A55(T) improvement itself).

Eight minor watercourses are crossed, each currently culverted under the A55(T). The culverts are located near Llain Ffwlbart, near the junction with Roman (Henffordd) Road, near Tan-yr-Allt cottages, at Tai'r Meibion Farm, at Wig Farm, at the site of Wig Bach, at Bryn Meddyg and at Pentre Aber Farm. Further investigation will be required on site to determine the condition of each culvert and suitability for connection prior to detailed design.

It is essential that any works do not pollute or damage the water environment of the watercourses, or increase flood risk. The Proposed Improvements must also follow the guidelines set out by the WFD legislation and not cause negative effects to stream water, biological or chemical quality.

The Proposed Improvement involves the on-line widening of this section of the A55(T) dual carriageway trunk road to current standards with hard strips. A new central concrete vehicle

containment barrier will be constructed and two existing cattle creeps will be extended. A new 1.6km county road will join the Tal y Bont interchange (Junction 12) with the Wig Crossing Cottages junction.

During construction it will be necessary to implement a wider culvert on streams 5 and 8 (see appendix K and N).

This report will establish any flood risk associated with the upgrading and upsizing of culverts, and suitable mitigation measures will be suggested and put in place to ensure flooding is not increased downstream of such changes. Measures will also be implemented to ensure that there are no negative effects to the water quality or increased flood risk through the construction or post construction of the culverts.

The report will also outline the Proposed drainage along the section with the inclusion of pollution prevention measures, pollution control deployment points (PCD's) and where possible the use of SuDS as a form of managing the runoff.

1.4 The Project Objectives and reasons for the Project

1.4.1 Welsh Government Objective and Mission Statement

The Welsh Government's mission is to:
"Promote the vision and transport strategy described in the Welsh Government's 'One Wales: Connecting the Nation', the Wales Transport Strategy, and the National and Regional Transport Plans".

1.4.2 Scheme/ Planning Objectives

The Proposed Improvement will contribute to achieving long-term sustainable development goals in Wales by adhering to the following principal objectives:

- improving pedestrian and cycling access connections to provide alternative, healthier forms of travel;
- alleviating flooding issues to ensure ongoing transport connectivity and resilience to climate change;
- improving the standards of a strategically important highway to ensure that it provides efficient future connectivity between communities and economic hubs;

- enhancing safe passage for wildlife underneath the section of highway to be improved to provide enhanced future connectivity for biodiversity at the locality, and;
- considering the aims of sustainable development within the design, construction and operation of the Proposed Improvement (use of SuDS where possible within the area).

2.0 Purpose of this Report

This report comprises the Flood Consequence Assessment (FCA) for the Proposed Improvement of a section of the A55(T). Described is the assessment of flood risks associated with the Improvement works. This includes an assessment of the baseline flood risks along the Proposed Improvement. The with-Improvement flood risks are also assessed and any mitigation measures required are identified. It is important to demonstrate that the proposed improvement will have an acceptable level of flood risk and that it does not have negative cumulative effects elsewhere.

2.1 DMRB and Wales Planning Policy Guidance

The assessment of flood risk for the Proposed Improvement has been carried out with reference to the guidance provided in the Design Manual for Roads and Bridges (DMRB) Volume 11, Section 2, Part 10, HD 45/09. Annexe I, Method F recommends that a flood risk assessment should cover the requirements of TAN15 (Planning Policy Wales, Technical Advice Note 15, Development and Flood Risk 2004).

Guidance in TAN15 states that flood risk must be considered over the anticipated lifetime of the development.

The Development Advice Map which accompanies TAN15 contains three zones (A, B and C with subdivisions C1 and C2) which trigger the appropriate planning tests in relation to Sections 6 and 7 and Appendix 1 of TAN15. These are as follows:

- Zone A - Little or no risk of fluvial or tidal flooding;
- Zone B - Areas known to have been flooded in the past, evidenced by sedimentary deposits;
- Zone C1 - Areas at risk of flooding from fluvial or tidal sources (based on EA extreme flood infrastructure, including flood defences; and
- Zone C2 - Areas at risk of flooding from fluvial or tidal sources (based on EA extreme flood outline for 0.1% annual chance event) and without flood defence infrastructure).

Transport infrastructure is considered in terms of the criteria defined in Section 5 of TAN15 as less vulnerable development. Such development can be permitted within Zone C subject to permissible criteria.

Appendix A1.14 of TAN15 defines that general infrastructure, such as a trunk road should be flood free during the 1% (1 in 100) annual chance fluvial flood event allowing for climate change over the intended development lifetime. It is accepted in TAN15 that developments may flood during more/ less probable events (taken to be a 0.1% (1 in 1000) annual chance event). Indicative acceptance criteria including the maximum depths and velocities of flood water during extreme events are given in Appendix A1.15 of TAN15.

2.2 Assessment Approach

Opportunities to reduce the threshold of flooding have been considered in the design of the Proposed Improvement. Any improvement in flood risk over the baseline must be balanced against the scale and cost of mitigation measures.

3.0 Existing Information

Requests for data and information in relation to flooding along the route were sent to NRW, Gwynedd Council and the North and Mid Wales Trunk Road Agency (NMWTRA).

NRW provided indicative information on surface water low flows through the Updated flood maps For Surface Water, groundwater locations and aquifer locations (see Appendix D for the updated surface water map).

There were no existing hydraulic models of the relevant watercourse catchments to inform a flood consequence assessment.

Gwynedd Council's as lead local flood authority provided information on known flood history.

NMWTRA provided information on culvert locations and flood history.

3.1 Site Context

The Proposed Improvement relates to an improvement of a 2.2 km section of the A55(T) from Abergwyngregyn to Tai'r Meibion. Through improving the road safety, additional drainage of the section will be included, combined with updating and improving current drainage. With improved drainage from the A55(T), the surrounding land may be a recipient of increases in water.

The Proposed Improvement crosses eight watercourses, summarised as follows:

- Stream 1 (Grid Reference: 262195 371160)
- Stream 2 (Grid Reference: 262502 371417)
- Stream 3 (Grid Reference: 262799 371613)
- Stream 4 (Grid Reference263080 371755)
- Stream 5 (Afon Wig) (Grid Reference: 263449 371917)
- Drainage ditch 5a (Grid Reference: approx. 263627 372010)
- Drainage ditch 5b (Grid Reference: approx. 263851 372102)
- Stream 6 (Grid Reference: 264012 372157)
- Stream 7 (Grid Reference: 264512 372369)
- Stream 8 (Grid Reference: 264976 372569)

All of the above watercourses will be considered as part of the FCA. Detailed analysis of steam 5 will be required due to the upsizing of the culvert capacity and the location of properties downstream. The flood risk associated with the upsizing will be assessed in relation to potential increased flood risk to downstream properties.

Other sources of flood risk which are considered in the FCA are pluvial (direct surface runoff), the effects of runoff from the Proposed Improvement and groundwater.

3.2 TAN15 Development Advice Map

The Development Advice Map (DAM) which supports TAN15 suggests that there are no areas at risk of fluvial or tidal flooding within the area of the Proposed Improvement. See Appendix A for the DAM for the Proposed Improvement area.

3.3 Flood Map and Modelling

A flood model has been developed for Stream 5 (Afon Wig) to assess the downstream flood risk to the Wig Crossing Cottages properties. Capacity checks have been made on all culverts, the result of which can be found in the drainage strategy report.

Stream 8 will require upsizing of the culvert. Further detailed assessment of Stream 8 in relation to flood risk is not required as there are no properties downstream and the size of the watercourse is of sufficient depths and width; therefore the upsizing works are not considered to increase risk elsewhere. A CCTV of the existing culvert associated with stream 8 showed that only highway drainage currently discharges to Stream 8, this is a contradiction to the OS water features layer.

Stream 5 (Afon Wig) will require further assessment as Wig Crossing Cottages are located downstream of the upsizing works. The upsizing of a culvert has the potential to increase flood risk as the volume of water able to flow downstream is increased. Hydraulic modelling of stream 5 illustrating the pre improvement flood risk followed by the post improvement flood risk would illustrate how the upsizing of the culvert would affect Wig Crossing Cottages.

Any increase in flood risk to these properties will be noted and suitable mitigation measures will be implemented and incorporated into the model.

Although the area is not located within the Development Advice Map Zones, stream 5 and the surrounding land is within the fluvial flood plain for the Afon Wig. The improvements will aim to illustrate that Wig Crossing Cottages combined with mitigation measures with face a reduced flood risk. Stream 5 will be modelled using the 1 in 100 year event + 30% allowance for climate change (1% AEP +CC) and the 1 in 1000 year (0.1% AEP)event. Using these return periods it will be possible to illustrate the worst case scenario. The upsized culvert will be designed for a 1 in 100 year +CC event (1% AEP +CC).

3.4 Surface Water Flood Map

An indication of areas potentially susceptible to surface water flooding is indicated on the NRW Updated flood maps for surface water (Ufmfsw). Although this is indicative only, it can provide a starting point to highlight existing areas which might affect and be affected by the Proposed Improvement.

The flood map identifies areas at risk of surface water flooding:

- High - 1 in 30 annual chance rainfall
- Medium - 1 in 100 (1% AEP) annual chance rainfall
- Low - 1 in 1000 (0.1% AEP) annual chance rainfall

These are considered indicative only and should be used in conjunction with local information. Further site specific assessments have been undertaken as part of the baseline assessment. The updated surface water flood map can be found in Appendix D.

3.5 Other sources of flooding

No areas of groundwater flood risk have been identified; this was confirmed through consultation with NRW, stating that the area is not at significant risk of groundwater flooding.

The stretch of the A55 between Abergwyngregyn and Tan y Lon is underlain by a Secondary B aquifer, the bedrock and predominantly unproductive aquifer for the drift/superficial as it consists of Till (Devensian).

Secondary aquifers include a wide range of rock layers or drift deposits with an equally wide range of water permeability and storage. Secondary aquifers are subdivided into two types:

- **Secondary A** have 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;

- **Secondary B** are predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. **Unproductive Strata** for the drift deposits / superficial have low permeability that have negligible significance for water supply or river base flow – these are generally shallow / thin deposits.

The floodplain map (see Appendix C) indicates that the fluvial floodplain within the Proposed Improvement area is associated with Afon Wig.

3.6 Flood History

The Proposed Improvement section of the A55 is known to flood regularly following prolonged periods of intense rainfall events. The following flooding information was provided by Gwynedd Council Highways department and NMWTRA:

November 2012

Total closure of the A55(T) for a period of 12 hours due to intense rainfall and saturated ground conditions.

2014

Lane closure between junction 11 and 12 due to a partially blocked culvert.

Isolated incidents of smaller flooding events have been a regular occurrence along this section of the A55(T) due to insufficient drainage including poorly maintained culverts and grilles.

December 2015

Flooding incidents affecting the A55 between J13, Abergwyngregyn and Tai'r Meibion occurred over the recent Christmas period and the event timeline was as follows:

- 25/12/15 - 18:23 - W/B Lane 1 closure due to surface water flowing onto carriageway from adjoining agricultural land at numerous locations;
- 26/12/15 – 07:05 – W/B fully closed due to amount / volume of water across carriageway (closed at J15);
- 26/12/15 – 07:33 – W/B remains closed & E/B closed due to volume of water (E/B closed at J11);
- 26/12/15 – 21:34 - W/B remains closed & E/B now open
- 26/12/15 – 23:56 – W/B reduced to Lane 1 closure (J13 – J12)
- 16/12/15 – Monday 04/01/16 - W/B Lane 1 closure (J13 – J12) remains due to ongoing water seepage onto carriageway

As previously, due to the adjacent agricultural land being totally saturated as a result of the recent rainfall and it being at a higher ground level, surface water was flowing onto the carriageway.

All existing trunk road surface water drainage infrastructure appeared to be operational although a large volume of stones/ debris was removed by machine from the stream at the inlet to the culvert at Tai'r Meibion (the last culvert travelling westbound prior to Tai'r Meibion farm). This stream had also been cleaned of similar debris following a flooding event on 12/12/15.

However, surface water was flowing onto the A55 at a number of locations from the fields and from access roads/ entrances along this section, which, due to the nature and restrictions of the existing alignment and infrastructure are very difficult to control.

It was noted that these 'streams' were being created due to the extremely saturated ground conditions and by watercourses being 'redirected' due to blocked culverts at higher ground and therefore not following the natural path.

3.7 Sustainable Drainage Systems (SuDS)

The use of SuDS within the proposed improvement has been considered and assessed. Filter strips, filter drains, over the edge drainage and a detention pond have been incorporated into the proposed design of the Improvement. As the need to minimise land take limits the scope for the implementation of further SuDS, the use of over-sized pipes has been included for temporary storage of surface water runoff.

The detention pond at the site of Wig Bach will be used as a settling bay for some of the surface water runoff to allow for sediment separation and removal of hydrocarbons and other pollutants.

Where drainage discharges directly into streams i.e. has not passed through the filter drains or detention pond, treatment and management of runoff will be carried out as closely as possible to the source of the run off to eliminate pollution entering the streams.

During the detailed design stage, additional SuDS would be considered and implemented where possible.

3.8 Pollution Containment Locations

Pollution control points would be installed at the outfalls of each watercourse, providing an opportunity for an enhancement measure as part of the scheme. . Access to these locations is expected to be available via the NMU route and the new county road and would be clearly sign-posted. Specific access locations would be identified during the detailed design stage.

3.9 Agricultural effluent waste management

The cattle creeps will require improved drainage systems to allow movement of livestock and agricultural machinery. The drainage is required to be directed away from watercourses as slurry from the underpasses may cause significant pollution to the streams. The slurry will build up over time as animal effluent mixes with rainwater to create a liquid mix. The drainage design for the cattle creeps will be confirmed during the detailed design stage, with agreement from NRW.

The new farm accesses are considered not to affect the current effluent management requirements of the farms. The movement of livestock will not be altered significantly. Any changes to this at the detailed design stage will be assessed and evaluated in consultation with NRW.

4.0 Baseline Flood Risks Assessed

The baseline flood risk conditions have been defined to compare with the post Improvement scenario. The hydrological and hydraulic assessments undertaken for the relevant watercourses are described below.

4.1 Hydrology

A series of flood frequency relationships were calculated based on industry best practice for all watercourses along the route of the Proposed Improvement.

Hydrology was developed for each of the streams within the Proposed Improvement.

The hydrology assessment can be found in Appendix O.

4.1.1 Small catchments

The peak flow for all streams and ditches which cross the route of the Proposed Improvement have been calculated using all catchment methods with reference to the Environment Agency Guidance June 2012 (Flood Estimation Guidelines). The peak flows were based on area weighting of FEH methods applied to the nearest suitable catchment above 0.5km^2 for which descriptors can be derived from the FEH CD-ROM.

All catchment descriptors were derived from FEH CD-ROM version 3. Statistical estimates used WINFAP version 3.0.003.

4.2 Hydraulic Assessments

As stated in section 3.3 each of the culverts carrying the streams below the A55 have been assessed for capacity during a 1 in 100 year event + 30% allowance for Climate Change (1% AEP +CC). Following this assessment it has been established that streams 5 and 8 currently do not have the capacity to cope under such storm conditions. Therefore these two streams will require upsizing to allow for increased capacity to cope with a 1 in 100 year + CC event (1% AEP +CC).

As there are no properties downstream of Stream 8, no further flood risk assessment was undertaken as the depth of the watercourse downstream (Deep due to erosion) was deemed to be of sufficient capacity.
Wig Crossing Cottages are downstream of Stream 5 (Afon Wig) therefore further analysis is required.
To test compliance with TAN15, analysis of the following events has been carried out for Stream 5 (Afon Wig):

- 1% (1 in 100) annual exceedance probability (AEP) plus a 30% increase in peak flows as climate change allowance.
- 0.1% (1 in 1000) annual exceedance probability (AEP).

4.2.1 Afon Wig

The flood risk to the Proposed Improvement and the effect on flood risk to Wig Crossing Cottages will require assessment to ensure no adverse impact on existing areas within close proximity to the upsized culvert. The scope to contribute to cumulative impacts further downstream will also be considered.

Hydraulic Model

The final flow estimates were calculated and it was agreed with NRW that these flows represented the flow of Afon Wig. These flows were input to the model for the 1 in 100 year event +CC(1% AEP +CC) and the 1 in 1000 year event (0.1% AEP) for both the pre and post improvement works.

Within the post improvement works model the flood bund has been included upstream of the A55 at a height of 900mm (500mm for the bund height, 400mm depth for the drainage ditch). Downstream the railway culvert has also been included within the model. The railway embankment has been picked up on the LiDAR 1m data and is represented in the model.

Once the models were successfully completed the results were analysed to establish the flood risk to Wig Crossing Cottages and the depth of water that would be seen. The models were then re-run with the addition of a wall surrounding the outer boundary of the properties to establish the minimum level of protection that would be required to protect the properties from flooding.

The wall ensured protection during the 1 in 100+CC (1% AEP +CC) and the 1 in 1000 (0.1% AEP). The height of the wall was established by using the ground elevations from the LiDAR data and adding min 300mm to the wall adjacent to No 4 Wig Crossing Cottages. The connecting wall to the rear of the properties was increased to a constant level of 16.280m elevation to ensure a constant level of protection and to ensure the lower section of the eastern wall meets the southern wall elevation. The total length of wall from Point A to Point I is 51.838m.

Additional drainage mitigation measures

In addition to the Wig Crossing Cottages wall, following concerns raised by NRW and the residents of Wig Crossing Cottages in relation to the potential build- up of surface water behind the proposed mitigation wall, there will be a commitment to ensure that the cottages are not at increased risk of surface water runoff from the surrounding area. There will be an additional outfall from the railway embankment of a minimum size of 300mm diameter. A minimum 300mm diameter pipe will also be incorporated within the surface water drainage to the south of Wig Crossing Cottages draining into the Afon Wig (Stream 5) from the Wig Crossing Cottages access track. The increased outfalls and drainage of surface water will ensure that Wig Crossing Cottages will not be at increased risk of surface water pooling behind the proposed mitigation wall.

4.3 Other Sources of flooding

4.3.1 Pluvial (direct surface runoff)

The Updated Flood Maps for Surface Water (UFMfSW) highlighted areas potentially at risk of flooding from surface water. Based on these maps and site observations of local topography, assessments have been undertaken of the areas likely to be susceptible to surface water flooding.
These areas have been identified specifically as:

- Junction 12 to Tal y Bont slip-road
- From the Wig Cottage junction (Grid Ref: 263426 371928) to the Wig Farm Junction (Grid Ref: 263656 372017) (Both lanes).

See Appendix D and E for the surface water flooding map of the Proposed Improvement area and the outline of the areas susceptible to flooding map.

4.3.2 Groundwater flooding

No locations of known groundwater flooding have been identified. Water quality constraints and potential impacts on aquifers are considered in the Road Drainage and the Water Environment chapter within the Environmental Statement.

There is no evidence of any existing groundwater flood risk based on the topography of the area; it is therefore considered unlikely to be a significant risk to the Proposed Improvement.

The management of groundwater is not considered to be an issue and will be controlled through geotechnical design.

5.0 Proposed Improvement

5.1 Main Sources of flood risk

The main sources of flood risk associated with the Proposed Improvement are:

- Pluvial flooding
- Surface runoff from surrounding fields

The Proposed Improvement would potentially have an adverse effect on flooding if progressed without mitigation measures at the Wig Crossing Cottages.

Table 5.2.2 summarises the current capacity of the culverts and the 1 in 100 year event +CC (1% AEP +CC) flows. Those culverts unable to cope with such flows have been incorporated into the drainage design to include upsized culverts the estimated figures can be found within the table (Colebrook and White, 1937-1939).

5.2 Hydraulic Assessments

The main area of concern is that of Wig Crossing Cottages located downstream of the outfall of the upsized culvert works. The upsizing of the culvert has been designed to allow flows of a 1 in 100 year +CC (1% AEP +CC) to pass through the culvert under the A55 without over-topping onto the A55. The study aims to identify flood risk with climate change from Afon Wig (Stream 5) to Wig Crossing Cottages and the proposed improvement.

The overall objectives are:

1. Procure a survey
2. Undertake hydrology assessment
3. Undertake 1D/2D hydraulic modelling
4. Provide estimated flood extent and depth maps
5. Establish suitable mitigation measures to protect Wig Crossing Cottages from flooding

The key objective of the hydrological assessment was to undertake a full hydrological analysis of the Afon Wig catchment in accordance with the FEH Statistical and ReFH methodologies, following the latest guidance. Peak flow has been produced for the 1 in 100 year event +CC (+30%) (1% AEP +CC) and the 1 in 1000 year event (0.1% AEP) flood events for use within the hydraulic model of the Afon Wig. The peak flow estimate for the 1 in 100 year event (1% AEP) has been adjusted for climate change by increasing the peak flow for the event by 30%.

The hydraulic model has been built to determine the flood risk to third party areas associated with 1 in 100 year event +CC (1%+CC) and the 1 in 1000 year event (0.1% AEP). The hydraulic model has been used to define flood zone depths and extents, indicating the areas that have increased flood risk post improvements.

The model was run using XPSolutions XPStorm software Version 2016 SP1; this is an integrated SWMM – Tuflow modelling package that has linked 1D – 2D capabilities. The model for this assessment was an unsteady linked 1D/2D model, to enable the production of flood maps.

Hydrology software used was WINFAP and ReFH. Further information on hydrology can be found in Appendix O.

Data Collection

Survey

- A detailed survey was carried out in November 2015.

- Two temporary stations were used to survey the river length
- Railway culvert size manually measured by YGC (tape measure)

Flow Information

- Q95 low flow discharge of 6.7 l/s (in 2008 NRW stated their estimate was 5.0l/s)
- No Previous Model was available
- No historic flood extents maps were available

Digital Terrain

- Lidar Data (1m Resolution) was made available from Geomatics/Environment Agency

Any Further Information

- Site visits
- Photographs
- Flood incident recollections from landowners

Hydraulic Coefficients

Below are Manning's n used for different OS Master-Map areas. (As suggested in ISIS help manual)

- General Surface-0.033
- Glasshouse-1.000
- Inland Water-0.030
- Landform-0.035
- Natural Environment-0.100
- Path-0.016
- Rail-0.020
- Road Or Track-0.014
- Roadside-0.030
- Tidal Water-0.020
- Unclassified-0.050
- Building-1.000
- Structure-1.000

Afon Wig sections were spaced at 15m intervals. Manning's roughness for channel was 0.040 based on Chow 1959 Manning's n for channels - c. clean, winding, some pools and shoals.

5.2.1 Afon Wig

Flood models were produced to illustrate the pre and post scheme flood outlines for both a 1 in 100 year + 30% (1% AEP +CC) to allow for climate change estimations and 1 in 1000 year +CC (0.1% AEP)event in relation to the upsizing of the culvert at this location. The model was developed to illustrate the flood risk pre-improvements and the flood risk post-improvements. The proposed improvements include improved drainage, incorporating upsizing of specific culverts that do not meet current capacity estimations.

Upsizing of culverts results in the streams being able to carry a greater volume of water at an increased rate. The upsizing of the culvert is of benefit to the A55 as surface water will be removed from the carriageway quicker; the risk of pooling will be significantly reduced, in addition the risk of surcharging at the upstream end will be reduced. There is however some concern that the increased volumes of water downstream may increase flood risk to properties downstream of the upsizing works. To reduce the velocity of flow within the culvert there will be energy dissipation measures included. This will have the combined effect of reducing the velocity and allow for free movement of migrating fish.

The model was developed to illustrate how the flooding pattern would be altered post improvement works.

From analysis of the flow path from past flooding events at this location, it has been established that the Afon Wig comes out of bank upstream of the A55, over-spilling onto the A55, then flows down the access road to Wig Crossing Cottages and over the agricultural fields. With the proposed upsizing of the culvert, the flow would be able to enter the culvert and remain within the culvert reducing the amount of out of bank flow as the water will be contained within bank from the inlet of the culvert. Upsizing of the culvert increased the carrying capacity of the culvert, resulting in a greater amount of water being able to enter the culvert as there are no restrictions in relation to size and capacity of the culvert. increasing the amount of water that is able to enter the culvert reduces the amount of water that is unable to flow down the culvert; therefore reducing the potential for water to be unable to enter the culvert and flow onto the carriageway. This corresponds to eyewitness accounts from Gwynedd Highways department.

The results generated from the model have been imported into GIS software to produce maps for easy comparison of the pre and post improvement scenarios. The maps produced from the hydraulic assessment can be found in Appendices P to Z.

Railway Culvert and Embankment

For both the pre and post models the culvert that is located downstream of Wig Crossing Cottages (Grid Ref: 263330 372304) which carries the Afon Wig under the railway line is **2.7m²**, when compared to the new A55 culvert (**3.6m²**,) it is roughly a third smaller but with a steeper gradient. The railway culvert has been incorporated into both the pre and post improvement models. The railway embankment has been defined within the 1m LiDAR. It is accepted by NRW and Gwynedd Council that the LiDAR elevations represent the embankment and that these elevations will allow for an accurate representation of the embankment and the representation of the flow path.

5.2.2 Model Results

See Appendix P to W for hydraulic modelling output maps.

Pre Improvement Outputs

A55 Current Culvert Capacity (900mm)	3.715m³/s
1 in 100 year +CC (1% AEP +CC) (1% AEP)	9.839m³/s*

*estimated from the 1 in 100 year flow from WINFAP with 30% added to allow for climate change.

1 in 100 year event + CC

The hydraulic model was developed using a hydrograph illustrating a 1 in 100 year +CC (1% AEP +CC) event for the Afon Wig. The output of the model illustrated the areas that are currently at risk of flooding.

The areas specifically illustrated from the hydraulic modelling at risk of flooding are:

- Pooling within field downstream of Tai'r Meibion
- From Tai'r Meibion to Stream 5 (Afon Wig) along the A55
- Downstream of the A55 at the outfall of Afon Wig
- Wig Crossing Cottages

1 in 1000 year +CC (0.1% AEP) event

The main areas currently at flood risk under the 1 in 1000 year +CC (0.1% AEP) event are namely:

- Downstream of Tai'r Meibion
- Between Tai'r Meibion to Stream 5 (Afon Wig)
- Upstream of A55 (pooling of water at the inlet to the culvert under the A55)
- Downstream of the A55 towards the railway
- Wig Crossing Cottages
- Downstream of the railway

The Pre Improvement models were developed using the current culvert size of 900mm. The railway embankment and railway culvert have been included within this model.

Verification

The flood outline from the hydraulic model corresponds with the flood outline witnessed during the November 2012 and December 2015 storms (although we do not have corresponding flow information for these events), where flood water also flowed down the access road to Wig Crossing Cottages.

Post Improvement Outputs without mitigation to Wig Crossing Cottages

Upsized A55 Culvert Capacity (3.6m^2)	9.839m^3/s
1 in 100 year +CC (1% AEP +CC)	9.839m^3/s*

*estimated from the 1 in 100 year flow from WINFAP with 30% added to allow for climate change.

1 in 100 year +CC (1% AEP +CC)

From the hydraulic model the post improvement flood risk areas are:

- Upstream of A55 (pooling of water at the inlet of the stream into the culvert behind the proposed bund)
- Approximately 100m from the A55 along the access track to Wig Crossing Cottages the model indicates that the stream would come out of banks at this point. Increasing the height of the wall at this location may ensure that the water remains within its channel. Increased depth of water in the agriculture land to the rear of Wig Crossing Cottages is approximately 200mm. See Appendix Q for flood map produced from the hydraulic modelling

1 in 1000 year +CC (0.1% AEP) event

See Appendices T to W for the hydraulic modelling flood maps.

From the hydraulic model the post improvement flood risk areas are:

- Pooling of water upstream of the A55 behind the proposed bund. This indicates that the bund would reduce the amount of water flowing onto the westbound carriageway of the A55.
- The model indicates that during the 1 in 1000 year +CC (0.1% AEP)event water would come out of bank and spill onto the Wig Crossing Cottages access track.

- Wig Crossing Cottages are still at risk of flooding during this event without the inclusion of any mitigation; however flood depths have reduced from up to 0.18m to a maximum of 0.104m post improvement.

The Post Improvement model was developed using the proposed upsized culvert of 3.6m^2. This size of culvert would allow for the 1 in 100 year +CC (1% AEP +CC) (1% AEP) flow to pass through the culvert.. The railway culvert and embankment were included within the model.

Summary of Pre and Post Model Results without mitigation measures

- The flood model indicates that post improvements the A55 would remain flood free during the 1 in 100 year event +CC.
- During the 1 in 1000 year +CC (0.1% AEP)event there would be over topping of the proposed flood bund along the westbound carriageway; the estimated flood depth of the over topping is up to 0.1m on the carriageway. The over spill water would be drained from the surface by the improved drainage.
- From the pre and post model results it is clear that Wig Crossing Cottages are still at risk of flooding without mitigation. Although the post model results indicate that the flood risk to Wig Crossing Cottages is reduced post upsizing of the culvert, suitable mitigation measures require consideration to ensure future resilience to Wig Crossing Cottages (see Post Improvements with mitigation options below).

Post improvements with mitigation Outputs

1 in 100+CC (1% AEP)

See Appendix V for changes to flood risk with mitigation map.
See Appendix X for the location and extent of the designed wall.

Wig Crossing Cottages are flood free during this event with the inclusion of the wall. Increasing the wall height by at least 300mm has illustrated that Wig Crossing Cottages would be protected from flooding during the 1 in 100 year event +CC (1% AEP +CC) combined with the upsized culvert.

1 in 1000 (0.1 % AEP)

See Appendix W for changes to flood risk with mitigation map.
See Appendix X for the location and extent of the designed wall.

Wig Crossing Cottages are flood free during this event with the inclusion of the wall. The increase in wall height of 300mm has illustrated that Wig Crossing Cottages would be protected from flooding during this return period combined with the upsized culvert.

The maps indicate that although Wig Crossing Cottages are protected up to the 1 in 1000 year (0.1% AEP) event due to the increased height of the boundary wall by at least 300mm wall, the mitigation measure of increasing the wall height surrounding Wig Crossing Cottages will result in increased flood depths within the adjacent agricultural land due to the deflection of the water from the Wig Crossing Cottages. As stated previously the area of analysis is located within the fluvial floodplain where there is presently a certain level of flood risk. The results of the flood modelling show an increase in flood depth to agriculture land but not increase flood risk to areas that were not previously susceptible to flooding.

Additional drainage mitigation measures

Following concerns raised by NRW and the residents of Wig Crossing Cottages in relation to the potential for surface water to pool behind the proposed wall, further drainage will be incorporated into the Proposed Improvement at this location to ensure that Wig Crossing Cottages are not at increased risk of surface water flooding. An additional outfall from the railway embankment (minimum 300mm diameter) to remove surface water will be provided. A minimum 300mm diameter pipe will also be incorporated within the surface water drainage to the south of Wig Crossing Cottages draining into the Afon Wig (Stream 5) from the Wig Crossing Cottages access track. The increased outfalls and drainage of surface water will ensure that Wig Crossing Cottages will not be at increased risk of surface water pooling behind the proposed mitigation wall.

Conclusion of results from the model

Table 5.2.2: Pre- and Post-Improvement Flows

Stream	Catchment Size km^2	1 in 100 flow m^3/s	1 in 100 +30% CC flow	Culvert size pre Improvement mm	Culvert capacity pre improvement m^3/s	Culvert size post Improvement m^3/s	Culvert capacity post improvement m^3/s
Stream 1	0.57	1.353	1.7589	1050mm	1.828*	1050mm	1.828
Stream 2	0.67	1.553	2.0189	1200mm	6.779	1200mm	6.779
Stream 3	0.83	1.864	2.4232	1050mm	7.698	1050mm	7.698
Stream 4	0.50	1.259	1.6367	900mm	3.092	900mm	3.092
Stream 5	2.53	7.188	9.839	900mm	3.715	$3.6m^2$	9.839
Stream 6	0.56	1.521	1.9773	900mm	2.443	900mm	2.443
Stream 7	0.412	1.142	1.4846	925mm	5.388	925mm	5.388
Stream 8	0.30	0.894	1.622	300mm	0.353**	1200mm	4.37

**Stream 1- assumptions made using best practice guidance on the slope as it varies along the culvert, smallest diameter pipe taken into account (600mm).*

***Stream 8- assumptions made using best practice guidance on the slope of the culvert as upstream invert/ level not known.*

Analysis of the culverts has been carried out using a 1 in 100 year +CC (1% AEP +CC) (1% AEP) event to establish if the culverts would have sufficient capacity to cope under such an event. The analysis clearly indicated that Streams 5 and 8 would not be able to cope with such an event. Therefore the drainage design of the proposed improvement will incorporate upsized culverts for streams 5 and 8.

The upsizing of the two culverts has been analysed in relation to flood risk and the results are described in the following sections.

Analysis of the maps produced from the flood model illustrate that **post** improvement works for the 1 in 100 year +CC (1% AEP +CC) (1% AEP) and 1 in 1000 year +CC (0.1% AEP)events, there would be an overall decrease in flood risk to the A55, Wig Crossing Cottages and surrounding area. The combined upsizing of the culvert on stream 5 combined with the construction of the flood bund on the south side (upstream) of the A55 and the flood wall on the outer boundary of Wig Crossing Cottages, illustrates successful flood alleviation. Although there are some agriculture land that will experience in increase in flood depths, the overall flood outline is reduced.

The flood maps illustrate that Wig Crossing Cottages would be at risk of flooding without the construction of the flood wall. Therefore the increased height of the boundary wall within the model has identified the level of protection required to ensure Wig Crossing Cottages remain flood free up to the 1 in 1000 year (0.1% AEP) event. (See Appendix P to W for hydraulic model results maps.)

The use of energy dissipation measures will reduce the velocity at which the water flows within the watercourse. The model illustrates that there is potential overbank spill downstream of the culvert, however the over spill is reduced post improvements and therefore flood risk is not increased.

The fields adjacent to Wig Crossing Cottages would see an increase of flood depths estimated up to 200mm during a 1000 year event. It is considered that no mitigation measures will be implemented here in regards to the increased flood depths as it is believed that the acquisition of land or agreement with landowner will be sought. The location of these fields is within the fluvial (Pre A55) floodplain of the Afon Wig and therefore naturally it would be expected that such locations would experience times of increased wetness. No other fields are expected to receive an increase in flood levels as a result of the proposed improvement.

5.2.1 Other watercourses, streams and ditches

All watercourses along the Proposed Improvement are marked on the maps in Appendices F to N. Locations of all culvert crossings and watercourses assessed for the FCA are listed in Table 5-1.

Where culverts have not been the subject of detailed hydraulic modelling they have been designed (as a minimum), to carry the 1% (1 in 100) chance flow including 30% allowance for climate change.

Table 5.1 Watercourse Culverts within the Proposed Improvement area

Stream	Current Culvert size	Proposed Works		1% +CC chance flow (m^3/s)	Pre Improvement culvert capacity	Post Improvement culvert capacity
		Type	Proposed works Size/ Length			
1	1050mm	• Extension of existing culvert at north side	• 9.198m	1.7589	1.828	1.828
2	1050mm	• Extension of existing culvert at north side	• 11.461m	2.0189	6.779	6.779
3	1050mm	• Extension of existing culvert at north side	• 8.800m	2.4232	7.698	7.698
4	900mm	• Extension of existing culvert at north • Extension of existing culvert at south	• 6.560m • 5.026m	1.6367	3.092	3.092
5	900mm	• Upsizing of existing culvert from 900mm • Extension of existing culvert at north • Extension of existing culvert at south	• $3.6m^2$ • 11.619m • 5.282m	9.839	3.715	9.839
6	900mm	• Extension of existing culvert at north • Extension of existing culvert at south	• 7.225m • 6.104m	1.9773	2.443	2.443
7	925mm	• Extension of existing culvert at north • Extension of existing culvert at south	• 10.786m • 14.709m	1.4846	5.388	5.388
8	300mm	• Upsizing of existing culvert from 300mm • Extension of existing culvert at north	• 600mm • 5.356m	1.622	0.353	2.185

		• Extension of existing culvert at south	• 2.387m			

Measures to manage and reduce the risk of blockage of culverts will be incorporated into the Proposed Improvement, such as improvements to screen arrangements. This includes the provision of safe access to the head of each culvert to facilitate regular maintenance and clearing. Consideration will also be given to the provision of coarse screens to reduce the risk of blockage.

Stream 8 is proposed to be lined for 200m, downstream of the A55(T). The lining is proposed to reduce the erosion rates currently occurring within the stream channel and banks. The lining will comprise of a flexible geotextile material that will line the stream channel and replicate the current channel. The stream material will be placed on-top of the lining to further replicate the natural channel. The incorporation of the lining will significantly reduce erosion rates. Installation of energy dissipation at the discharge outfall of stream 8 will reduce velocities.
The overall risk to the Proposed Improvement from the culverted streams is low/ negligible.

5.3 Pluvial/ direct surface runoff

See Appendix E for Flood Prone areas map.

It is clear from the past flood incidences that there are specific 'hotspots' for flooding incidents, namely:

- Between Junction 12 and the Tal y Bont Interchange both directions
- From Tai'r Meibion to Junction 13 Abergwyngregyn (west bound)

5.4 Runoff from the Improvement

The drainage from the road is designed such that the peak discharge from the proposed road drainage system will be restricted to one third of the existing runoff rates.

5.4.1 Mitigation of direct runoff to and from the Proposed Improvement

The pluvial (direct surface runoff) to the base of earthworks embankments and the top of cuttings will be intercepted and diverted to receiving watercourses. Flows will be controlled through the provision of drainage to the top and bottom of cuttings and embankments. To mitigate against flooding as a result of runoff from the fields. A min 400mm x 700mm wide channel will be installed along top of the south embankment of the Proposed Improvement.

Runoff from the impervious areas created by the Proposed Improvement will be attenuated by a storage/detention/balancing pond along the route (See Appendix L). The surface runoff from the road will be limited to one third of the existing runoff rates. Further opportunities to improve the runoff to attenuate to Greenfield rates (pre A55) will be sought through the development of the detailed design stage.

Discharge flows will be restricted using controls, such as hydro brakes or orifice plates. Attenuation will be provided by ponds designed in accordance with CIRIA C753 SUDS. Oversized pipes may be considered for storage in specific situations where space does not facilitate use of detention ponds. Suitable access provision will be provided to all storage facilities to allow for future maintenance.

As a consequence it is considered that no adverse impact on flood risk will arise from the surface water runoff from the Proposed Improvement.

5.4.2 Drainage Design

Currently the surface water run-off from the carriageway is collected via a series of filter drains along the verges to the eastbound and westbound carriageways. These filter drains discharge into a number of culverts carrying the natural watercourses beneath the carriageway.

The existing filter drains within the verge to the eastbound carriageway are to be removed and replaced with new. The existing filter drains within the verge to the westbound carriageway are to be removed and replaced with a series of hydraulic surface water channels with carrier pipes running beneath in addition to a new filter drain, this is to help accommodate any catchment runoff that might find its way passed the cut off system.

All effort will be made to reconnect the existing land drains to the south into the new concrete cut-off channel located behind the new bund. If this cannot be achieved they will be connected in to the new highway drainage system.

The concrete cut-off channel and bund has been designed to accept run-off from the adjacent catchment area (including land adjacent to Tai'r Meibion Farm) up to the boundary with Roman Road. From inspection on site, the Roman Road has a point drainage infrastructure that intercepts run-off from further up the hillside.

The existing culverts along the route of the proposed improvement require extending in length to accommodate the proposed works. A condition report shows the culverts to be acceptable from a condition point of view and reveals no major structural defects.

As part of the improvement works along the A55, the existing drainage arrangements are to be modified in accordance with the proposed carriageway profile.

This existing drainage summary should be read in conjunction the Road Drainage and Water Environment chapter of the Environmental Statement.

SuDS

The Proposed Improvement aims to minimise land take therefore the following SuDS have been considered appropriate for the drainage design, filter drains, filter strips, over the edge drainage and detention pond.

SuDS will be considered further at the detailed design stage of the Proposed Improvement and implemented were possible with agreement with NRW.

To improve access safety to the upstream trash screen of Stream 1, improvements will be made to the existing screen. The improvements will not have an adverse effect on the flood risk to the area. See Appendix Z1 for the detailed drawing of the proposed improvement works to Stream 1.

5.4.3 Erosion Prevention and Sediment Control Measures

Erosion control measures are required for construction areas where the ground surface will be disturbed by clearing, grading, fills, excavations and other construction activities. When developing an effective Erosion and Sediment Control Plan, there are several important concepts to consider:

- Timing - schedule work to minimize overall impacts
- Stage work - identify and process critical areas first
- Minimise disturbance - create buffers & reduce mass grading
- Pre-construction - during preliminary design and prior to on site grading activities
- Pictures/Video - documentation throughout life of project

Proposed Erosion Prevention and Sediment Control Plan

The first aim of the erosion prevention and sediment control plan should be to minimise erosion by reducing disturbance and stabilising exposed materials. The plan will then consider control measures to minimise the release of mobilised sediment which result despite the erosion control measures. It is necessary to consider how the impacts of the development may affect the relevant catchment or the river basin. The Water Framework Directive (WFD) requires the preparation of River Basin Management Plans (RBMPs) showing all significant impacts to the waters in a particular river basin. The interaction of new impacts from highway works with existing impacts may well produce cumulative impacts.

A cumulative impact is such where two or more streams in the same river basin are affected by the same project. This is likely to arise when a road runs parallel to a watercourse for over a kilometre. Assessment should consider the impacts to the receiving river as well as the streams themselves, even if the river is remote from site.

The RBMP produced by the Environment Agency (EA) will show where development in a river basin may have increased rates of run-off. Where highways are being improved and include existing culverts, an assessment should be made of the culvert's capacity, even if it will not be affected by the project.

To reduce increased risk from erosion and sediment mobility in the Proposed Improvement scheme baffle weirs on culverted watercourses flowing to open streams will be used.

Temporary Effects

Temporary effects from the construction of a project may be cumulative. For example, spoil from an excavation could be washed into a river as a result of a severe rainfall event. Depending on the nature of the watercourse, small discharges of spoil could accumulate on the river bed, leading to a risk of ecological damage to any fish and their spawning areas.

There can be a particular risk if the material has been imported to site, as its presence may cause a change to the chemical as well as physical quality of the water. Details of further assessment criteria can be found in chapter 5: Procedure for Assessing Impacts (5.49) in the DMRB, Volume 11, Section 3, Part 10, HD 45/09.

Proposed Controls

Baffle weirs will be put in place as a form of energy dissipation on the downstream outlet of culverts 1, 2, 3, 5 (Wig), 6 and 8 which flow into an open stream/river. The reduction in speed (energy) of the water will reduce the rate of erosion and the speed of transportation of sediments downstream. The baffle weirs were chosen as they allowed fish and eels to move freely up and down the streams through the culverts.

Streams 1, 2, 3, 5 (Wig), 6 and 8 will be modified to accommodate the new baffle weirs.

Streams 1 and 8, which currently have significant erosion problems, will be significantly improved post Proposed Improvement. The addition of baffle weirs will reduce the velocity at which the water currently flows through the streams and will therefore reduce the rate of erosion specifically within these two streams. Stream 8 will be lined with a geotextile material which will replicate the stream bed, reducing negative effects on the hydromorphology and hydrogeomorphology whist reducing erosion rates and improving the current issues of the stream.

Following the guidelines in the DMRB, Volume 11, Section 3, Part 10, HD 45/09, steps will be followed to ensure the risk of increased erosion does not occur and increased sediment mobilisation is not increased. Measures to prevent erosion are more effective than controlling sediment once mobilised. Within the project area there are 4 defined smaller catchments. Streams 1, 2 and 3 form part of the Ty'n Hendre catchment, stream 4 forms part of an un-named catchment, stream 5 part of the River Wig catchment and streams 6, 7 and 8 form part of another un-named catchment.

There is potential for cumulative impacts of increased sediment and erosion to the three main rivers (Ty'n Hendre, Un-named (stream 4) and Afon Wig)) as they have two or more streams flowing into them. It is estimated that the construction phase of the project will not increase erosion or sediment within the streams. The use of baffle weirs will further slow the speed of the water which will reduce erosion rates for the long term.

The nature of the topography of the area results in high runoff rates (for geology and soil type see chapter 5.5, Environmental Statement). The area comprises mainly unimproved agricultural land. Potential impacts from sediment mobilisation and erosion will not be increased during or as a result of this Proposed Improvement post works.

Streams with significant erosion problems (1 and 8) will be significantly improved post Proposed Improvement. The addition of energy dissipation measures will reduce the velocity at which the water currently flows through the streams; therefore reducing the rate of erosion specifically within these two streams.

6.0 Summary

6.1 Baseline Flood Risks

1. The baseline flood risks along the route of the Proposed Improvement have been identified and assessed.
2. Hydrological and hydraulic calculations and modelling have been undertaken to confirm the level of flood risks associated with Afon Wig.
3. The Proposed Improvement crosses eight watercourses.
4. Flood history has been gathered which highlights the following existing risk areas:
    - Between Junction 12 and the Tal y Bont Interchange
    - From Tai'r Meibion to Junction 13 Abergwyngregyn
5. The conveyance capacities of the culverts of the streams along the route have been assessed.

6. Qualitative assessments have been undertaken of the likely overland flow paths from existing stream culverts and field crossings which are affected by, or could impact the Improvement.
7. Other sources of flood risk which are considered in the FCA are pluvial (direct surface water runoff), the effects of runoff from the Proposed Improvement and groundwater.
8. Locations of existing surface water runoff (pluvial) flood risks have been identified.

6.2 With Proposed Improvement Flood Risks

Mitigation measures have been incorporated into the Proposed Improvement design to ensure that flood risks are managed and that there are no adverse impacts to the downstream properties of Wig Crossing Cottages.

1. Afon Wig- To mitigate the increased capacity of the culvert upstream of the Wig Crossing Cottages to ensure no increased flood risk to these properties. Upsizing from a 900mm (current capacity of 3.715m^3/s) pipe to a 3.6m^2 culvert allowing the 1 in 100 year event +CC (1% AEP +CC) flow of 9.839m^3/s (an additional 5.6294m^3/s of capacity). Energy dissipation devices will be constructed to reduce the velocity downstream of the culvert. The flood maps produced from the hydraulic modelling illustrate that Wig Crossing Cottages are at risk of flooding following the upsizing of the culvert. This flood risk is reduced through the construction of localised flood defence wall surrounding the outer boundary of Wig Crossing Cottages (as seen in appendix X) the provision of property level protection (if deemed necessary as secondary protection).
2. Stream 8 will be fitted with an upsized culvert to allow increased surface water drainage to be discharged into the watercourse. Upsizing from a 300mm pipe with a current capacity 0.353m^3/s, to a 1200mm pipe allowing up to 4.37m^3/s of flow . The 1 in 100 year event +CC (1% AEP+ CC) flow is estimated to be 1.622m^3/s. By increasing the cross section of the culvert, the velocities will be reduced though most of the storm events, up to an including the 1 in 100yr event (1% AEP +CC).
3. To reduce discharge rates to those of pre-improvement rates and where possible to one third of the existing highway runoff rates a detention pond will be constructed to store the increased surface water before discharging to the streams.
4. Culverts on the watercourses have been sized to convey at least the 1 in 100 year event +CC (1% AEP +CC) events including 30% climate change allowance to ensure no surcharge at the inlet.
5. The 1 in 1000 year event (0.1% AEP) at each culvert location has been assessed and no flood risk arises upstream.
6. The risk of blockage at culverts has been assessed. Measures are incorporated into the design to manage the risk. These include improved safe access to facilitate regular maintenance and

clearing and the provision of increase grillage size. Consideration will also be given to the provision of coarse screens.

7. No locations of known groundwater flooding have been identified. Based on the topography (Sloping ground) of the area, it is considered unlikely that groundwater flooding will be a significant risk to the Proposed Improvement. Any ground water will be managed through a series of existing land drains and highway fin drains.
8. It is considered that the overall flood risk associated with the Proposed Improvement can be managed within the proposed scheme design such that it remains operational under flood conditions up to and including the 1 in 100 + CC (1% AEP +CC) without causing any adverse impact to existing flood risk areas.
9. Construction of a flood bund and channel from the inlet of Stream 8 to beyond the inlet of Stream 4 will reduce the risk of flooding from surface runoff from the upstream fields adjacent to the A55. This cut-off system will also convey any water that may come out of bank of any watercourses upstream back in to the corresponding watercourse downstream.
10. Cut off channel and highway drainage are designed to operate within their existing catchments

Appendices

Appendix A - Development Advice Map TAN15 (2004)

Appendix B - Location and extent of Proposed Improvement Works

Appendix C - Outline of Floodplains

Appendix D - Outline of areas susceptible to Surface Water flooding

Appendix E - Outline of Areas Prone to Flooding

Appendix F - Location of the streams within the Proposed Improvement area

Appendix G - Stream 1

Appendix H - Stream 2

Appendix I - Stream 3

Appendix J - Stream 4

Appendix K - Stream 5

Appendix L - Stream 6

Appendix M - Stream 7

Appendix N - Stream 8

Appendix O - Hydrology Assessment

Appendix P - Hydraulic Assessment - Pre 1 in 100 +CC event

Appendix Q - Hydraulic Assessment- Post 1 in 100+CC

Appendix R- Appendix S- Hydraulic Assessment- Post 1 in 100+ CC with mitigation

Appendix S- Hydraulic Assessment – Pre 1 in 1000

Appendix T- Hydraulic Assessment Post 1 in 1000

Appendix U- Hydraulic Assessment – Post 1 in 1000 + mitigation

Appendix V- Hydraulic Assessment- Post Improvements changes to flood risk 1 in 100+CC

Appendix W- Appendix Y- Hydraulic Assessment- Post Improvements changes to flood risk 1 in 1000.

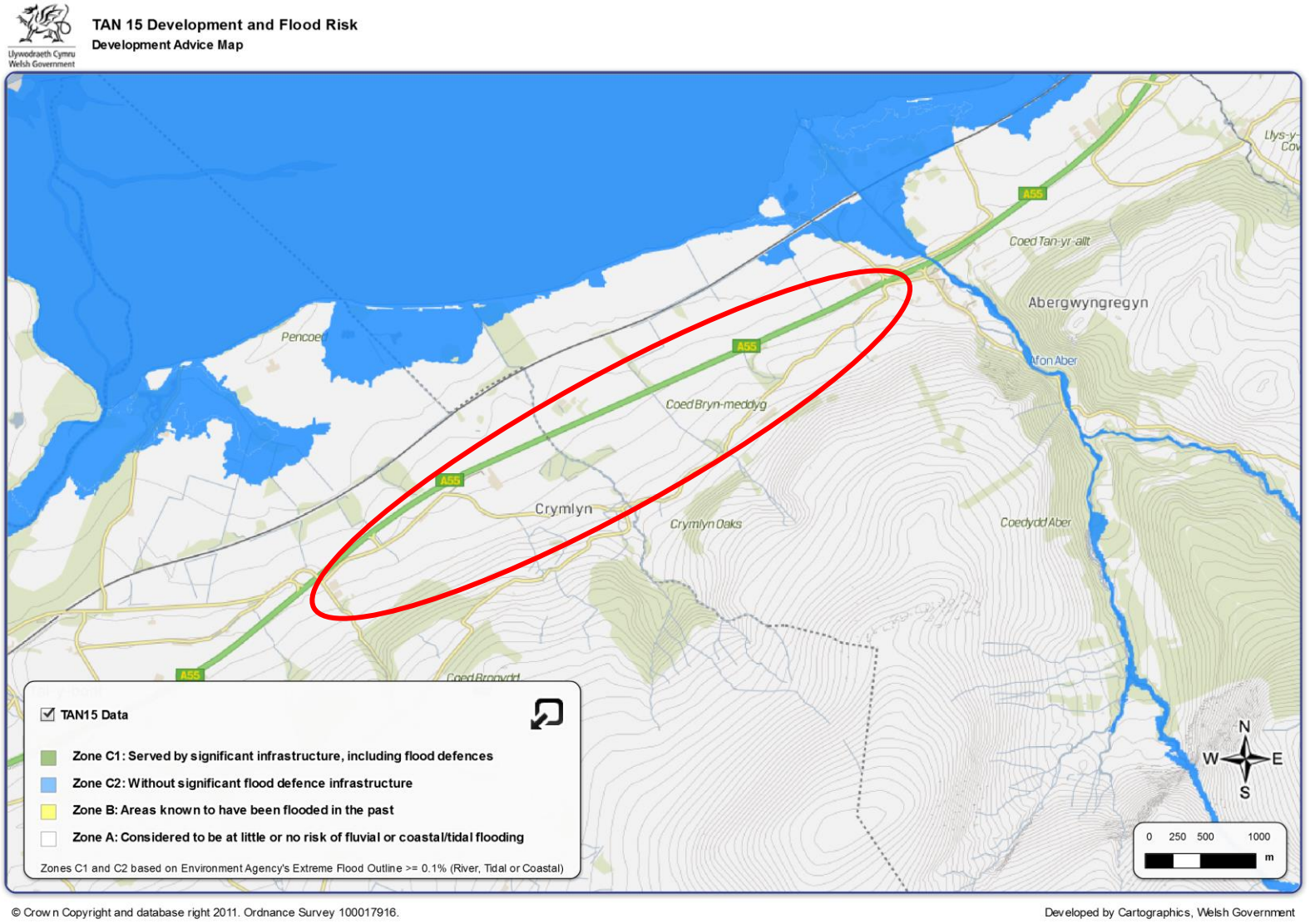
Appendix X- Watershed Analysis Wig Crossing Cottages using LiDAR data.

Appendix Y- ReFH plot scale method- adjusted catchment size following guidance from the SuDS manual

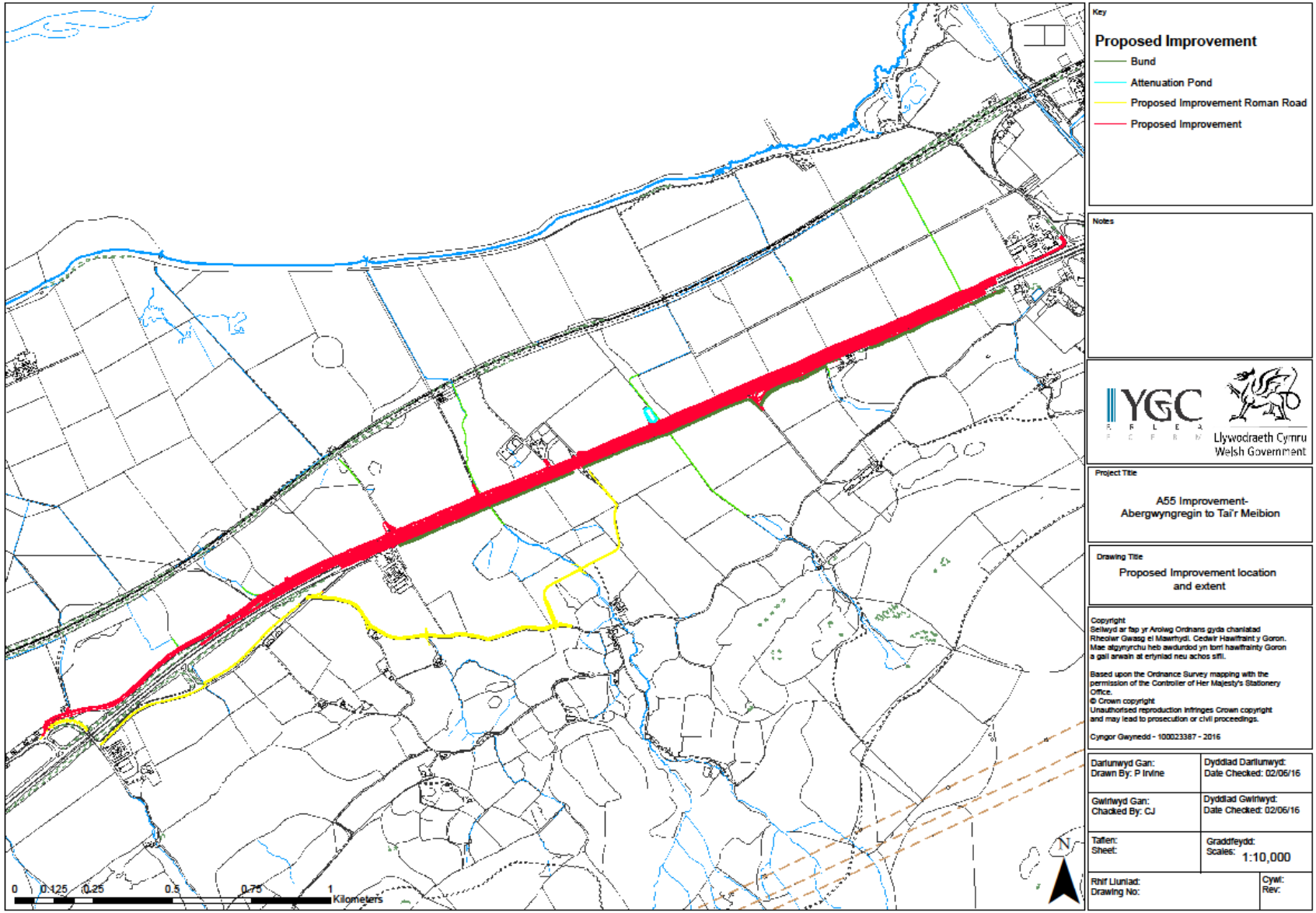
Appendix Z- Location and Extent of the proposed mitigation for Wig Crossing Cottages- Wall

Appendix A- Development Advice Map TAN15 (2004)

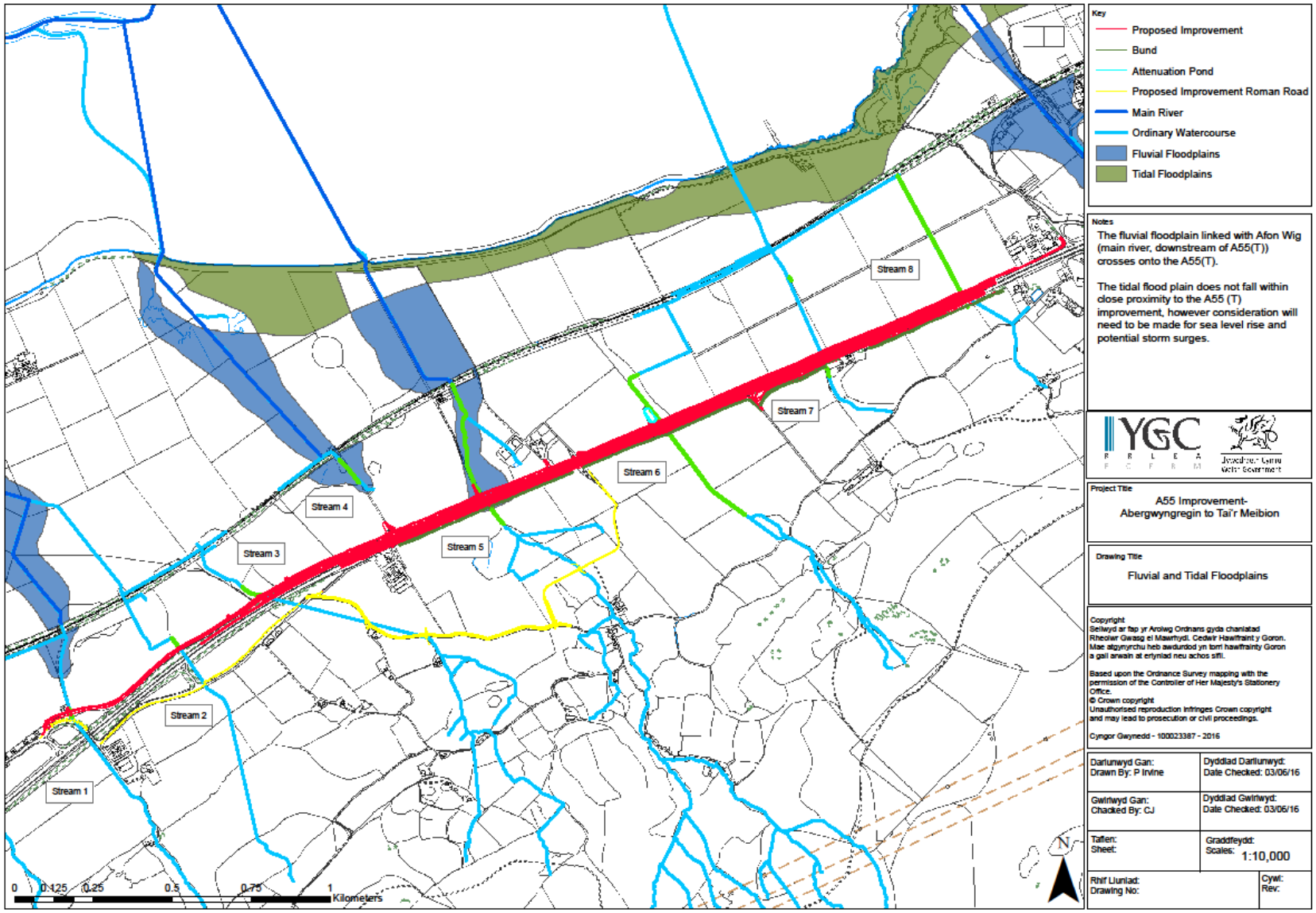
Proposed Improvement circled in red.



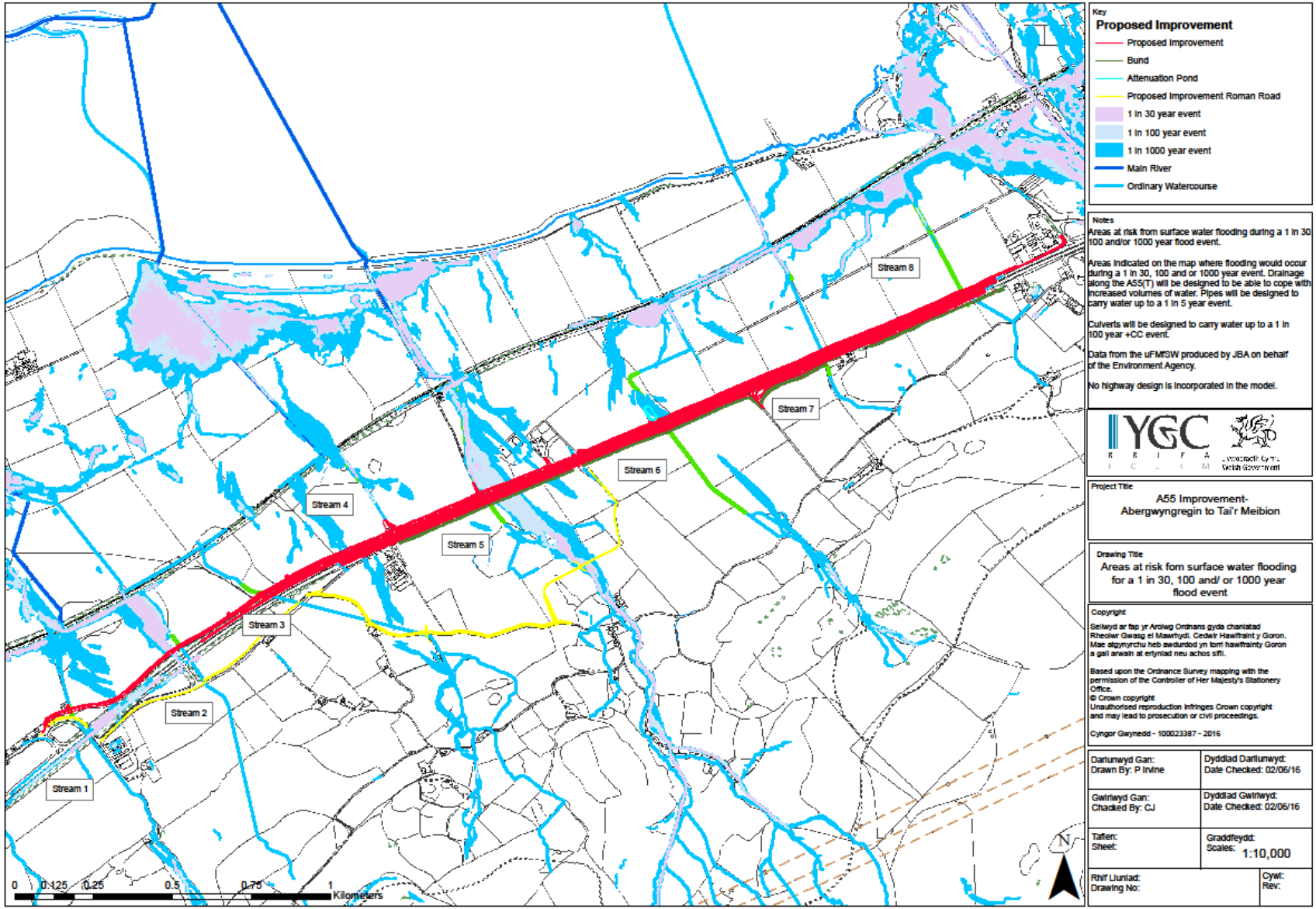
Appendix B- Location and extent of Proposed Improvement Works



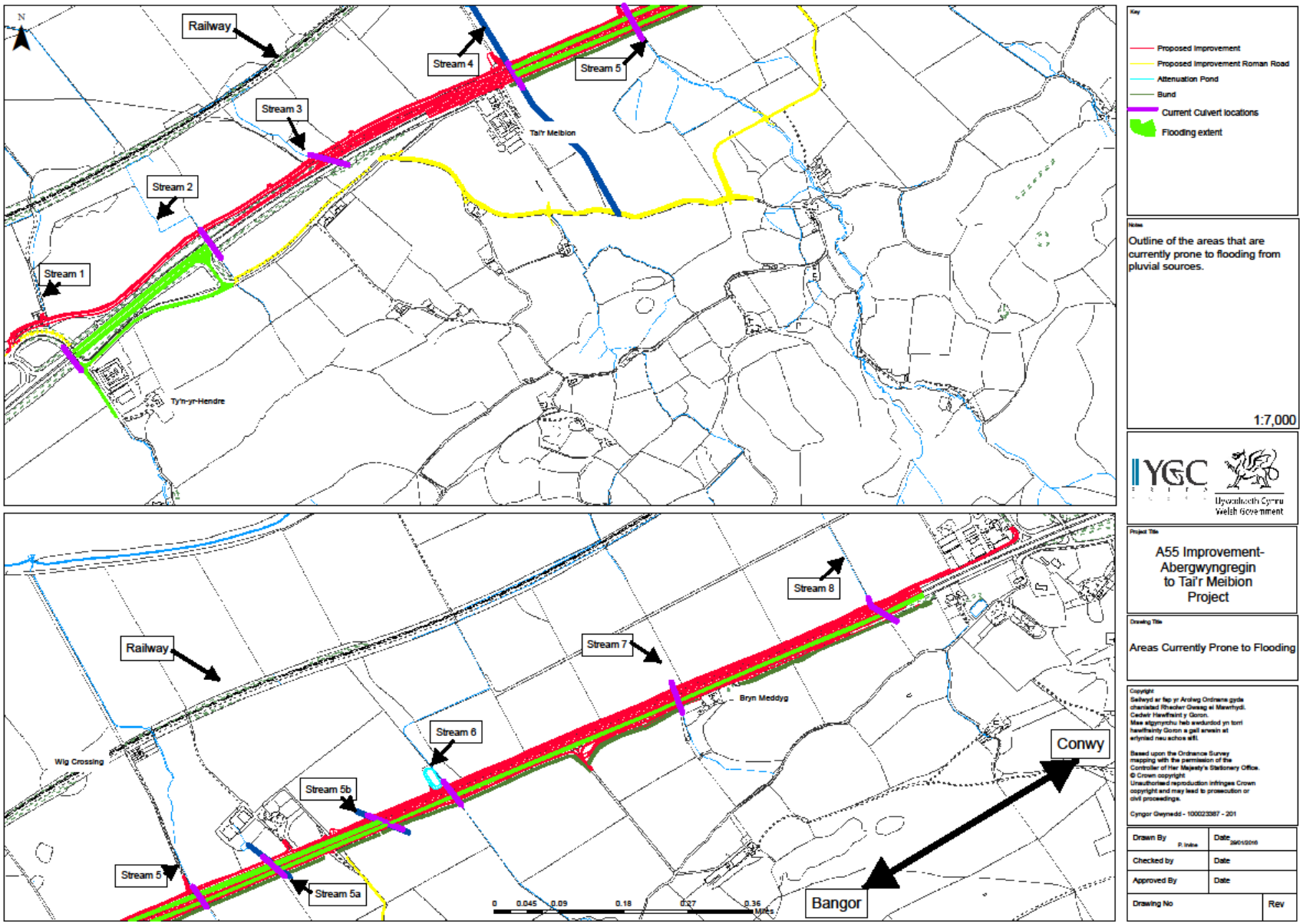
Appendix C- Outline of Floodplains



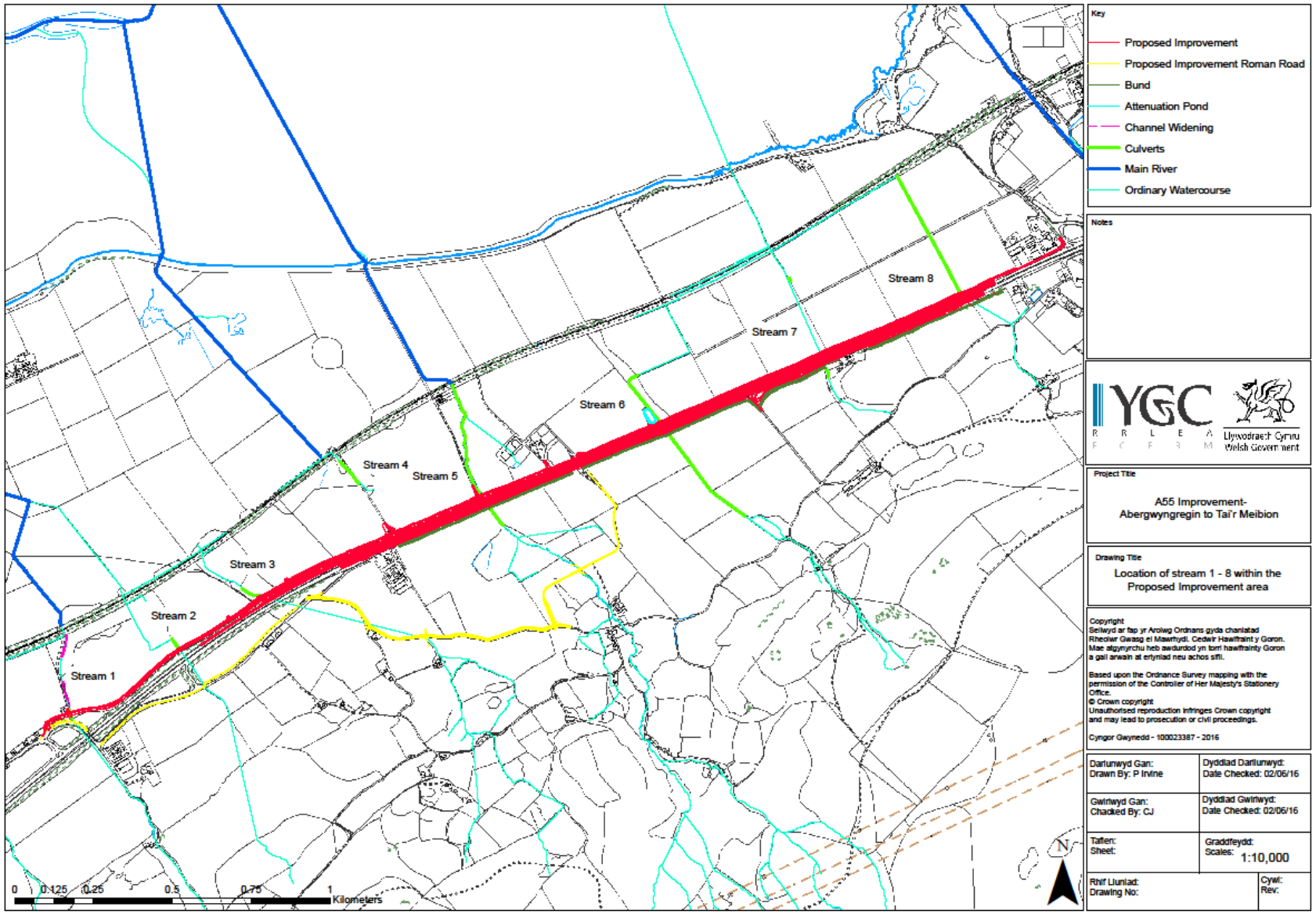
Appendix D- Updated Flood Maps for Surface Water



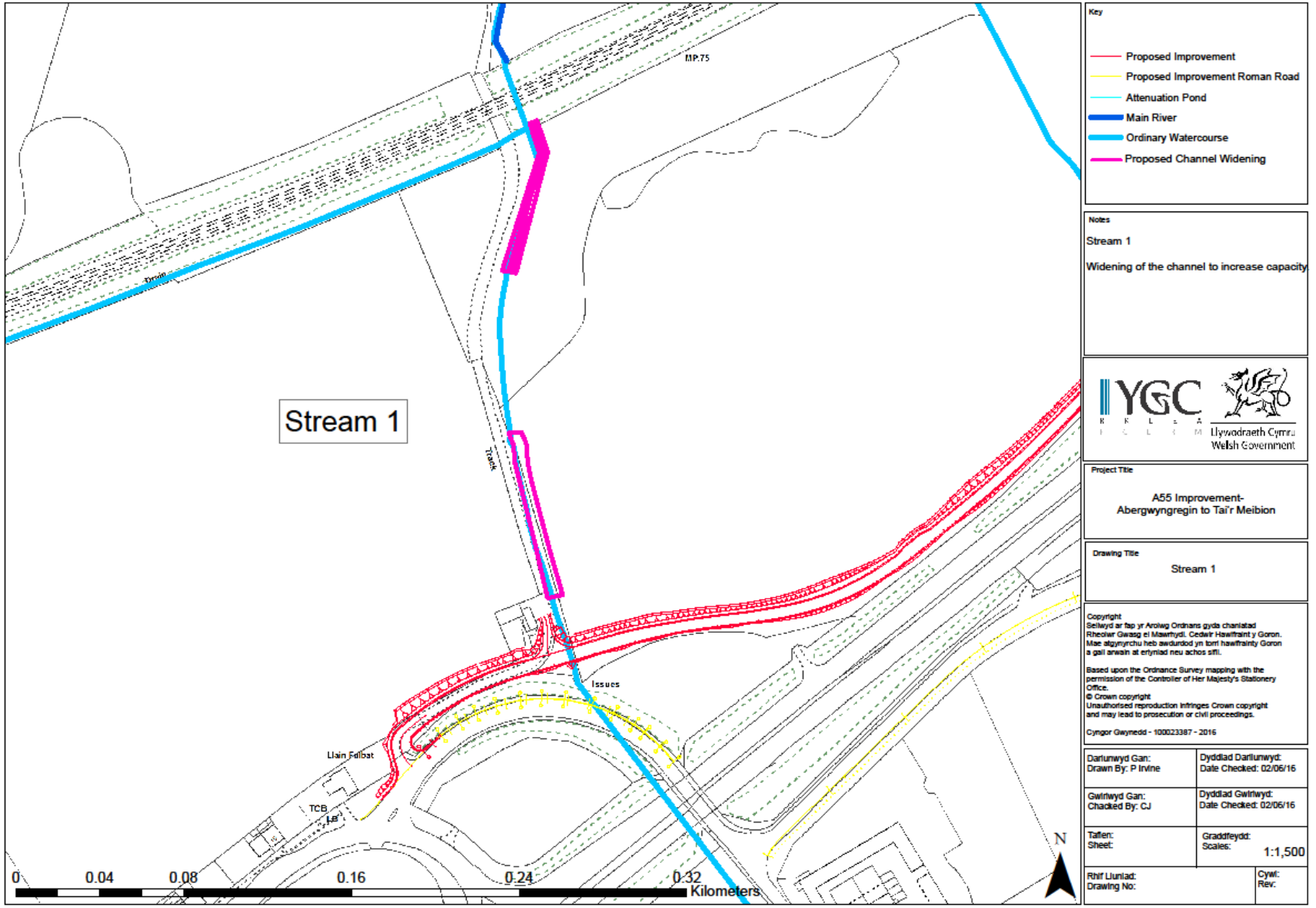
Appendix E- Outline of Areas Prone to Flooding



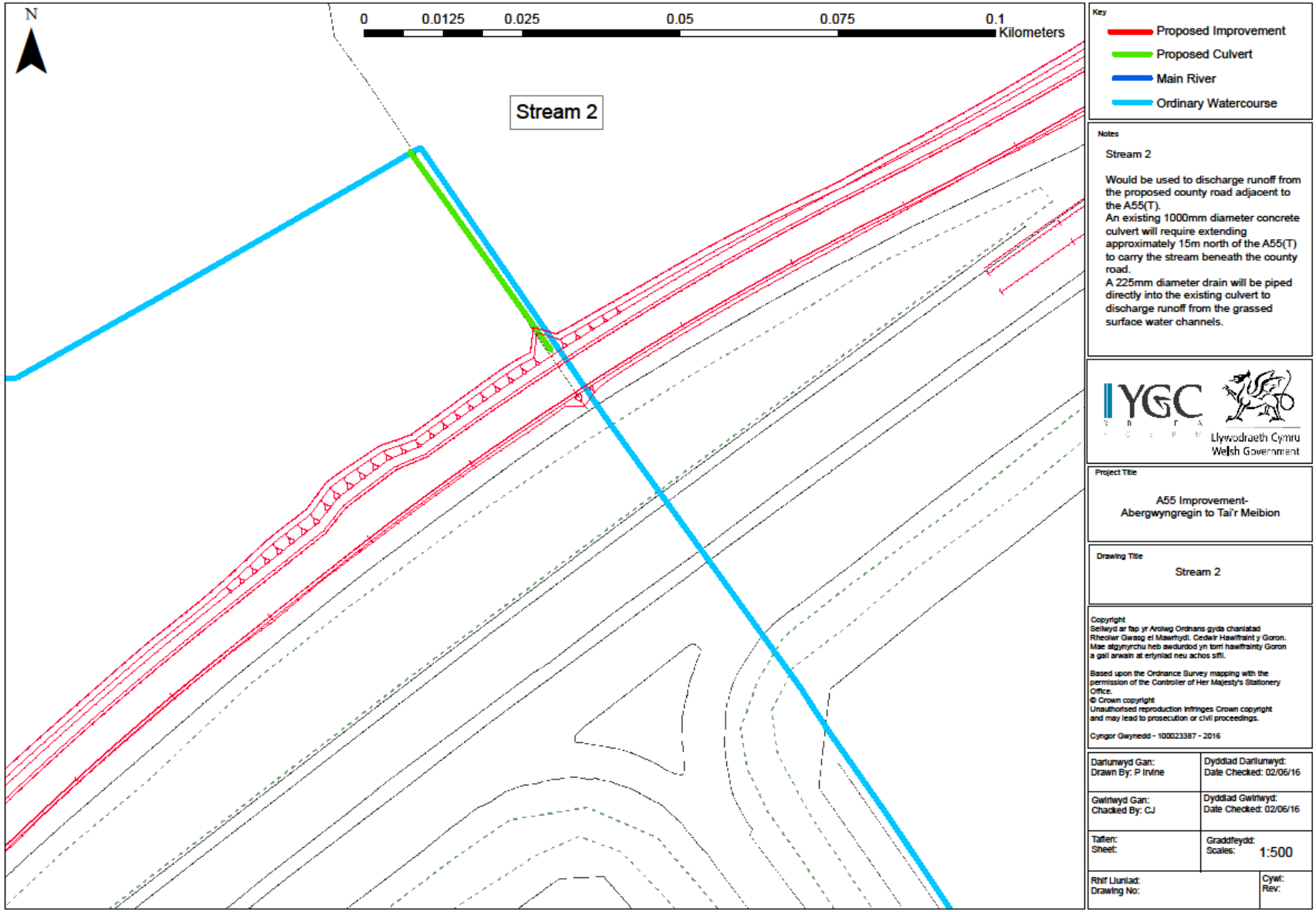
Appendix F- Location of the streams within the Proposed Improvement area



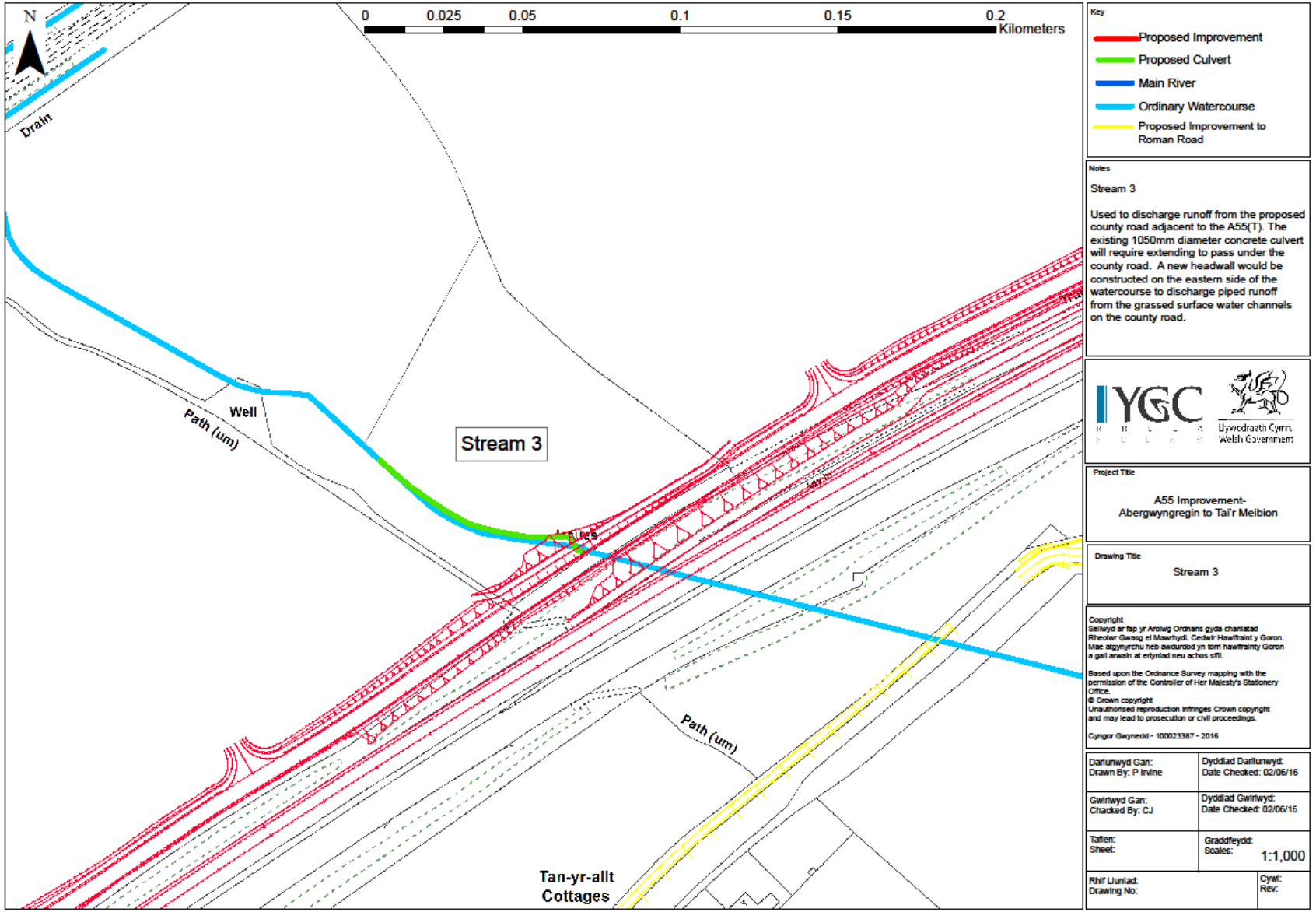
Appendix G- Stream 1



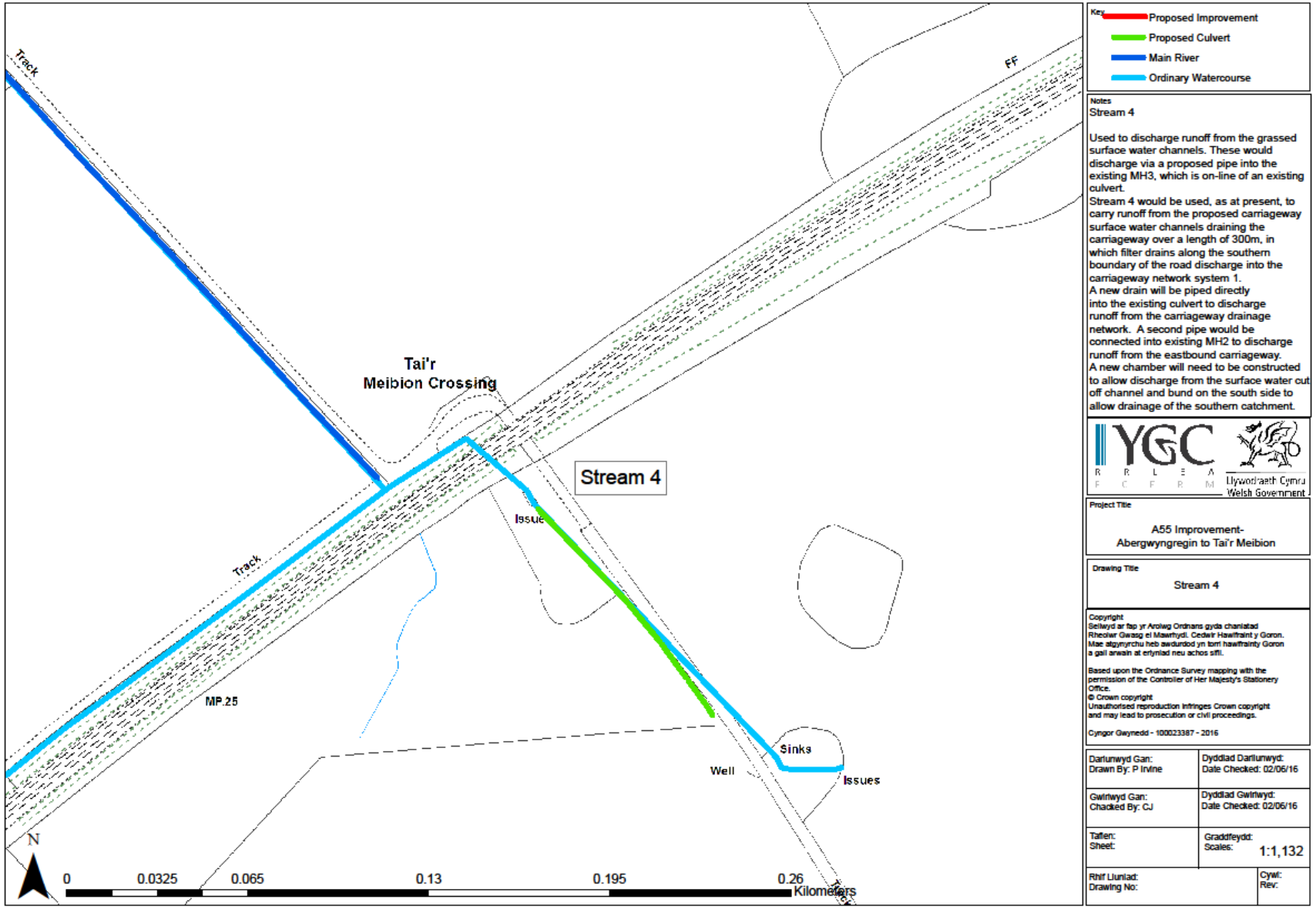
Appendix H- Stream 2



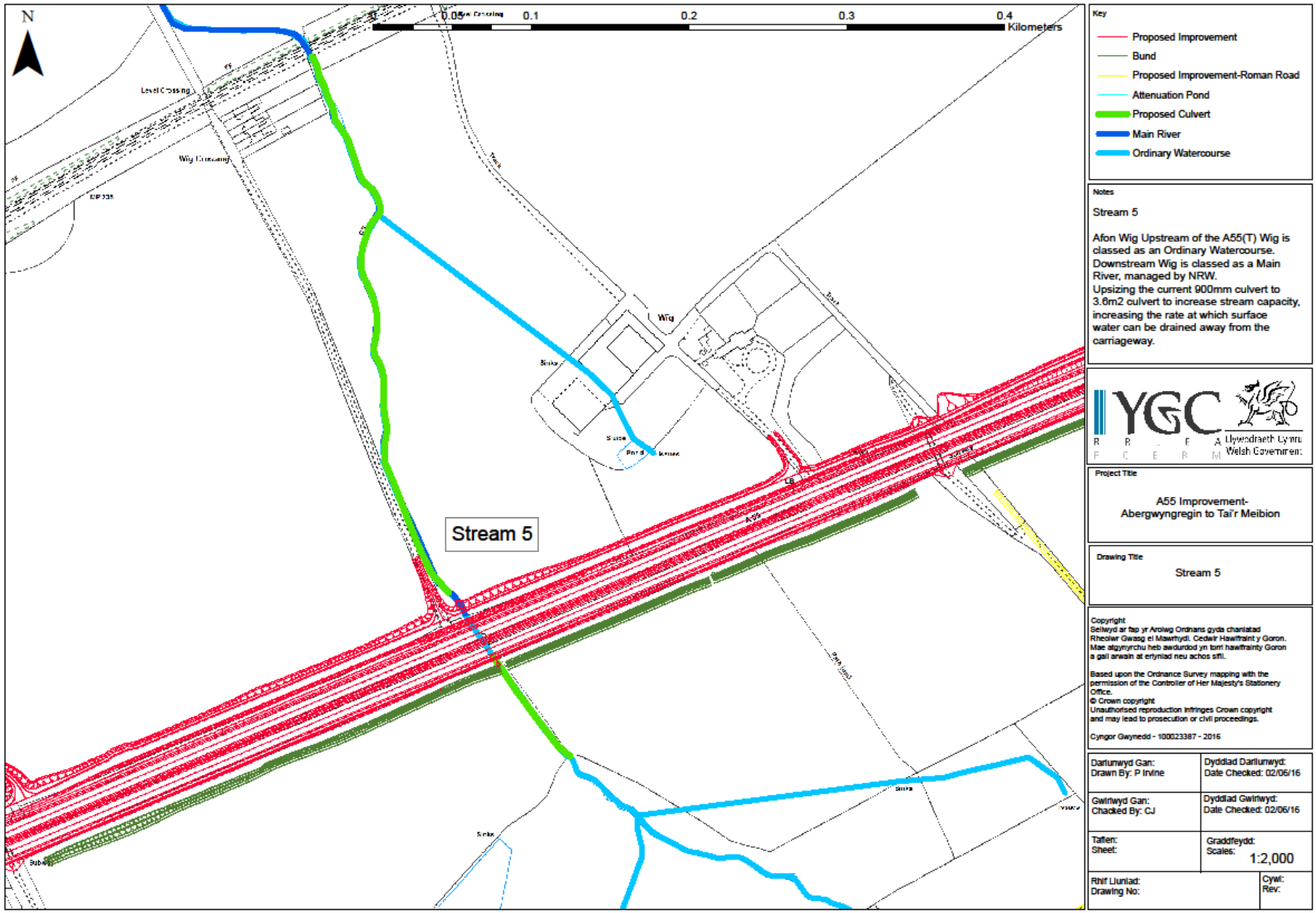
Appendix I- Stream 3



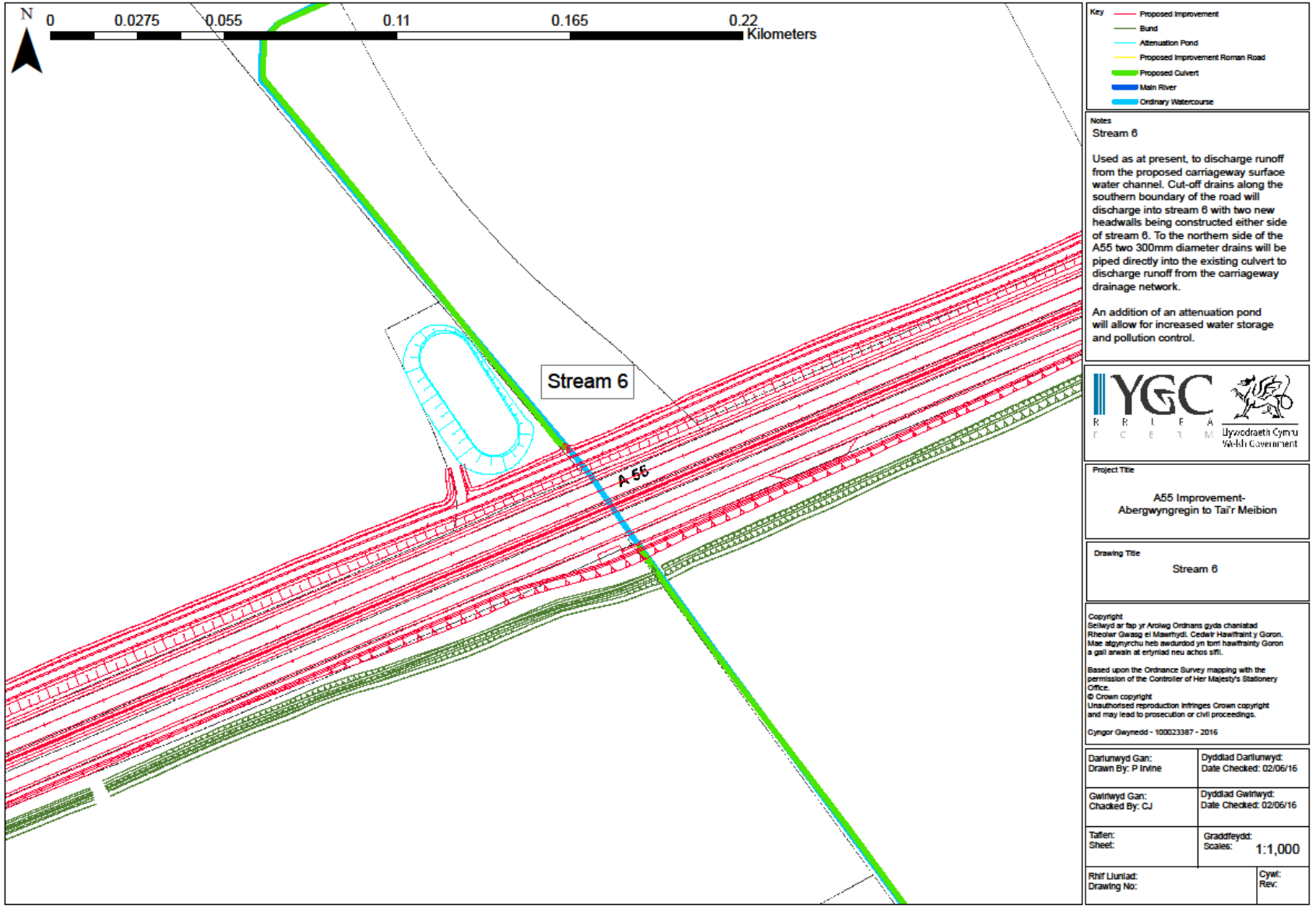
Appendix J- Stream 4



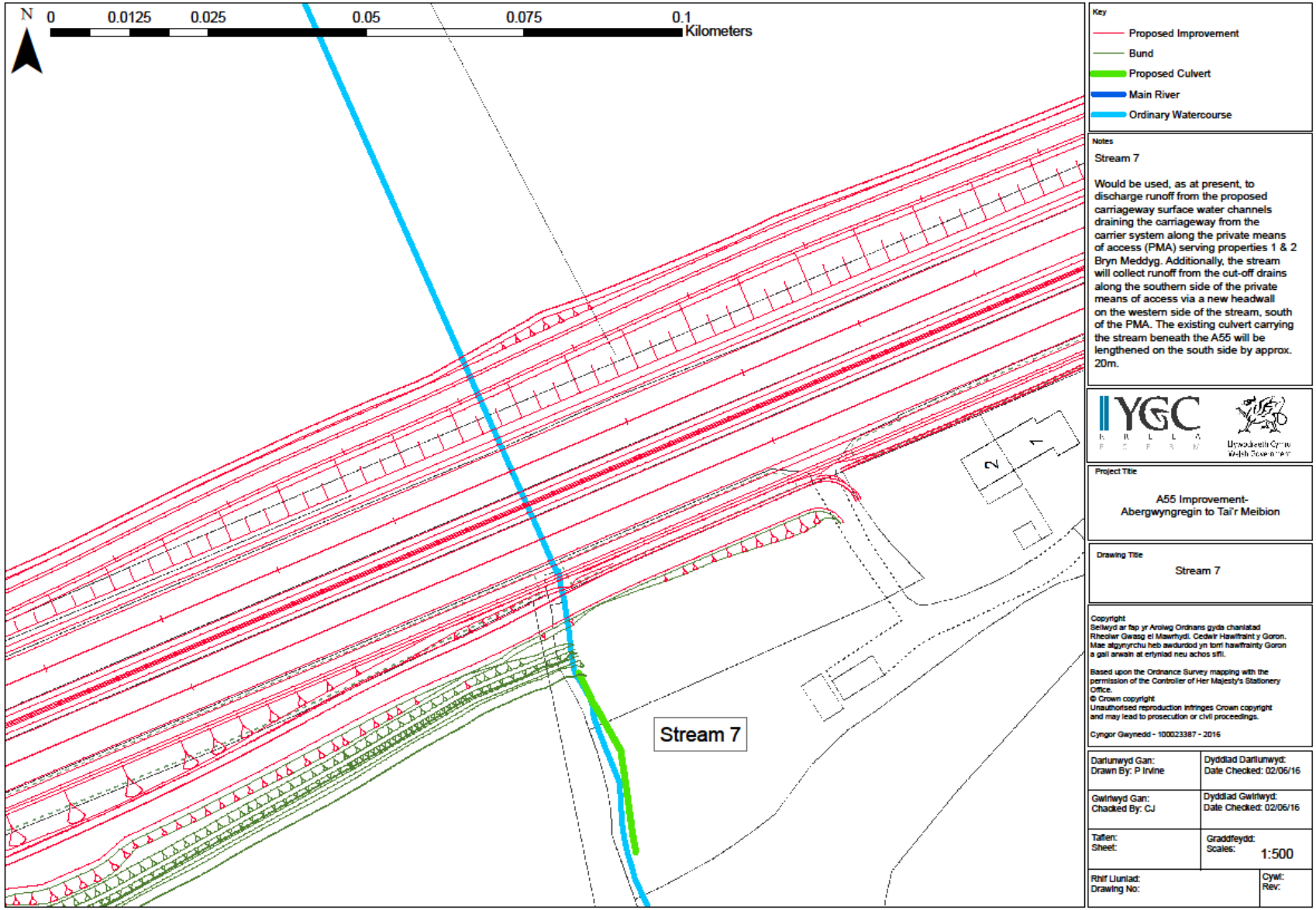
Appendix K- Stream 5



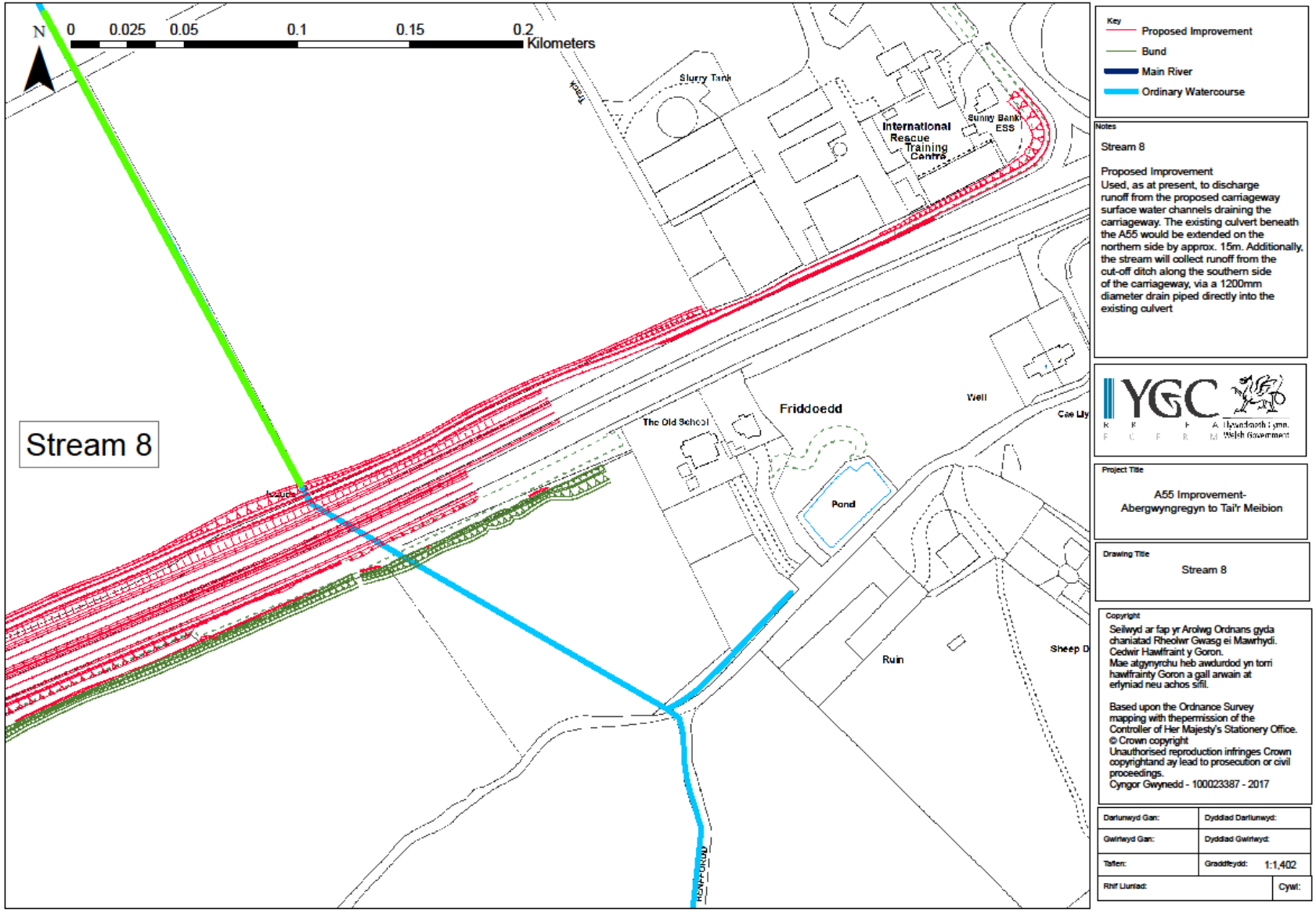
Appendix L- Stream 6



Appendix M- Stream 7



Appendix N- Stream 8



Appendix O- Hydrology Assessment

The Flood Estimation Handbook (FEH) Statistical and Revitalised Flood Hydrograph (ReFH) methods

Summary

A flood estimation calculation form (attached below) was sent to Natural resources wales in March 2016, the comments received indicated that there were some concerns regarding the methodology due to the updated recent guidance. We are currently moving to the latest methods and will update the hydrology methodology when ReFH 2.2 is implemented. Regardless of the above Natural Resources Wales carried out a check on the flows predicted and where happy with the flows proposed therefore these were not changed for the purpose of this study.

FEH Statistical

The FEH Statistical method applies a statistical analysis to a dataset of gauged stations in the UK and recorded AMAX data. The L-moments of a pooling group of hydrologically similar catchments are used to derive a flood frequency growth curve for each of the analysed catchments. An estimate of QMED is obtained from catchment descriptors (values representing variations between catchments) and is typically adjusted using nearby donor stations by data transfer.

An initial pooling group was created in WINFAP FEH 3 software with 2000 years of station data, using the latest WINFAP 3.3.4 station data available from the National River Flow Archive website. All stations 'not suitable' for pooling were removed. A review of the remaining stations was carried out based upon catchment descriptors. This was carried out for each catchment with an aim of reaching 500 years of data to create the final pooling group.

Revitalised Flood Hydrograph (ReFH 2)

The ReFH method is an improved rainfall runoff method. It relies on extrapolated rainfall data and catchment descriptors, in its simplest form, to predict hydrographs and peak flows for specific return periods.

The recommended storm duration calculated from catchment descriptors was generated for each individual catchment.

Recent research suggests that calibration of ReFH using data transfer from a gauging station is only beneficial if the gauging station is nearby and on the same watercourse as the study site.

The results from the ReFH and FEH Statistical methods carried out are presented in the following sections.

Available Data

The FEH provided flood peak data for 1000 gauging stations when it was first published. In 2005 HiFlows-UK dataset version 1 was released. Since then the data set has been updated again in 2008, 2009 and 2011. The HiFlow-UK dataset builds upon the original FEH research.

Primarily there are two main uses for the HiFlows-UK dataset:

1) Possible to use stations suitable for pooling to create pooling groups.
2) Possible to consider stations suitable for Q_{med} as potential donor sites.

Statistical method is based on a much larger dataset of flood events, and has been more directly calibrated to reproduce flood frequency on UK catchments, often prefer it to any rainfall runoff approach.

One of the most significant aspects of ReFH (Revised Flood Hydrograph Method), is that the design event was calibrated to match, on average, flood frequency curves derived from pooled analysis of 100 gauging stations. It is this reason ReFH tends to give peak flows that are much more consistent with those from the FEH statistical method.

Using the catchment data from the FEH CD-ROM 3 to generate a data base for each catchment, further analysis was carried out for each catchment using ReFH and WINFAP FEH 3 to establish a clear understanding of the hydrology of each catchment. Both forms of software were used during analysis to enable a statistical approach to be explored. When analysing the results, the software that produced the greatest peak flow i.e. the worst case scenario will be adopted.

Flood estimates for small catchments of <25km^2 are particularly hard to estimate as there is a limited data within the datasets of such catchments. Flood peaks on small catchments are much more susceptible to be influenced by local features- flow diversion, field drainage or storage of flood water behind culverts, bridges or embankments. Deriving digital catchment descriptors can also be difficult for small catchments.

Although the WINFAP FEH 3 software uses real-life catchment descriptors to compare the examined catchment against gauged catchment data. Due to the nature of the catchments in the study area, there were limited numbers of catchments with similar characteristics. Where possible during the statistical analysis donor stations with suitable similar characteristics were used.

Catchment Descriptors (CDs) are used to numerically describe the hydrological conditions within a catchment. Catchment descriptors have been obtained initially from the FEH CD-ROM 3. The main catchment descriptors used in the FEH method calculations have checked for consistency:

- URBEXT (Urban Extent)
- BFIHOST (Base flow index hydrology of soil types)
- SPRHOST (Standard percentage runoff hydrology of soil types)
- SAAR (Standard annual average rainfall)
- PROPWET (Proportion of time the catchment is wet)
- FARL (Measure of lakes, storage and reservoir influences)

Adjustments and Assumptions

Due to the small size of a number of the stream catchment areas, these were not represented on the FEH CD-ROM and therefore a number of assumptions and adjustments have been made.

The catchment descriptors derived from Stream 1 from the FEH CD ROM have been applied to streams 1, 2,3 and 4. The area of each of the streams has been adjusted to represent the individual catchment areas.

The catchment descriptors derived for stream 6 have been applied to stream 6, 7 and 8 with the adjustment of the individual catchment size.

Due to the close proximity of the streams to the chosen 'donor' catchment descriptors (stream 1 and stream 6) it was deemed suitable that using the nearby stream catchments would sill produce accurate flow estimations.

Catchment size has been calculated using OS map data and land observations.

The catchment for stream 5 was picked up on the FEH CD ROM and therefore was used to represent Stream 5.

Stream Catchments within the Proposed Improvement area

Stream 1

Catchment Descriptors (from FEH CD-ROM)

Grid Reference:	262195 371160
AREA	0.57km^2
BFIHOST	0.534
SPRHOST	33.98
URBEXT 1990	0.00
URBEXT 2000	0.00
FARL	1.00
PROPWET	0.59
SAAR	1268mm
DPSBAR	137.3m/km
DPLBAR	1.38km

Qmed Estimate

Catchment Descriptor Qmed Estimate:	0.488 m^3/s
Donor Adjustment or Catchment Descriptors?	CD
Donor Station (where applicable):	N/A
Final Qmed Estimate:	0.488 m^3/s

Growth Curve

Method: Pooling Group (minimum 500 years in line with current FEH recommendations)
Curve Distribution: **GL**

Return Period (yrs)	2	5	10	25	50	100	200	500	1000
Scaling Factor	1.000	1.357	1.624	2.020	2.368	2.771	3.239	3.980	4.651

Final Flow Estimates

Return Period (yrs)	2	5	10	25	50	100	200	500	1000
WINFAP	0.488	0.663	0.793	0.986	1.156	1.353	1.582	1.943	2.271

(Flow m^3/s)									
ReFH (Flow m^3/s)	0.33	0.45	0.54	0.68	0.79	0.91	1.04	1.22	1.42

Stream 2

Catchment Descriptors (from FEH CD-ROM)

Grid Reference:	262502 371417

AREA	0.67km^2
BFIHOST	0.534
SPRHOST	33.98
URBEXT 1990	0.00
URBEXT 2000	0.00
FARL	1.00
PROPWET	0.59
SAAR	1268mm
DPSBAR	137.3m/km
DPLBAR	1.38km

Qmed Estimate

Catchment Descriptor Qmed Estimate:	0.560 m^3/s
Donor Adjustment or Catchment Descriptors?	CD
Donor Station (where applicable):	N/A
Final Qmed Estimate:	0.560m^3/s

Growth Curve

Method: Pooling Group (minimum 500 years in line with current FEH recommendations)

Curve Distribution: **GL**

Return Period (yrs)	2	5	10	25	50	100	200	500	1000
Scaling Factor	1.000	1.357	1.624	2.020	2.368	2.771	3.240	3.981	4.652

Final Flow Estimates

Return Period (yrs)	2	5	10	25	50	100	200	500	1000
WINFAP (Flow m^3/s)	0.560	0.760	0.910	1.132	1.327	1.553	1.815	2.231	2.607
ReFH	0.39	0.53	0.64	0.79	0.92	1.07	1.22	1.43	1.67

(Flow m^3/s)									

Stream 3

Catchment Descriptors (from FEH CD-ROM)

Grid Reference:	262799 371613

AREA	0.83km^2
BFIHOST	0.534
SPRHOST	33.98
URBEXT 1990	0.00
URBEXT 2000	0.00
FARL	1.00
PROPWET	0.59
SAAR	1268mm
DPSBAR	137.3m/km
DPLBAR	1.38km

Qmed Estimate

Catchment Descriptor Qmed Estimate:	0.672 m^3/s
Donor Adjustment or Catchment Descriptors?	CD
Donor Station (where applicable):	N/A
Final Qmed Estimate:	0.672m^3/s

Growth Curve

Method: Pooling Group (minimum 500 years in line with current FEH recommendations)

Curve Distribution: **GL**

Return Period (yrs)	2	5	10	25	50	100	200	500	1000
Scaling Factor	1.000	1.357	1.625	2.021	2.370	2.773	3.242	3.984	4.656

Final Flow Estimates

Return Period (yrs)	2	5	10	25	50	100	200	500	1000
WINFAP (Flow m^3/s)	0.672	0.913	1.092	1.359	1.593	1.864	2.180	2.679	3.130
ReFH	0.48	0.65	0.79	0.98	1.14	0.32	1.50	1.77	2.06

(Flow m^3/s)									

Stream 4

Catchment Descriptors (from FEH CD-ROM)

Grid Reference:	263080 371755

AREA	0.50km^2
BFIHOST	0.534
SPRHOST	33.98
URBEXT 1990	0.00
URBEXT 2000	0.00
FARL	1.00
PROPWET	0.59
SAAR	1268mm
DPSBAR	137.3m/km
DPLBAR	1.38km

Qmed Estimate

Catchment Descriptor Qmed Estimate:	0.437 m^3/s
Donor Adjustment or Catchment Descriptors?	CD
Donor Station (where applicable):	N/A
Final Qmed Estimate:	0.437m^3/s

Growth Curve

Method: Pooling Group (minimum 500 years in line with current FEH recommendations)

Curve Distribution: **GL**

Return Period (yrs)	2	5	10	25	50	100	200	500	1000
Scaling Factor	1.000	1.357	1.624	2.019	2.368	2.770	3.239	3.979	4.650

Final Flow Estimates

Return Period (yrs)	2	5	10	25	50	100	200	500	1000
WINFAP (Flow m^3/s)	0.437	0.593	0.709	0.882	1.034	1.210	1.415	1.738	2.031
ReFH	0.29	0.40	0.48	0.59	0.69	0.80	0.91	1.07	1.25

(Flow m^3/s)									

Stream 5

Catchment Descriptors (from FEH CD-ROM)

Grid Reference:	263449 371917

AREA	2.56km^2
BFIHOST	0.478
SPRHOST	39.29
URBEXT 1990	0.00
URBEXT 2000	0.00
FARL	1.00
PROPWET	0.59
SAAR	1427mm
DPSBAR	232.1m/km
DPLBAR	2.72km

Qmed Estimate

Catchment Descriptor Qmed Estimate:	2.580m^3/s
Donor Adjustment or Catchment Descriptors?	CD
Donor Station (where applicable):	N/A
Final Qmed Estimate:	2.580m^3/s

Growth Curve

Method: Pooling Group (minimum 500 years in line with current FEH recommendations)

Curve Distribution: **GL**

Return Period (yrs)	2	5	10	25	50	100	200	500	1000
Scaling Factor	1.000	1.374	1.661	2.096	2.487	2.946	3.491	4.369	5.180

Final Flow Estimates

Return Period (yrs)	2	5	10	25	50	100	200	500	1000
WINFAP (Flow m^3/s)	2.580	3.546	4.284	5.398	6.397	7.569	8.953	11.180	13.229
ReFH	1.75	2.38	2.86	3.53	4.08	4.66	5.26	6.10	7.07

(Flow m^3/s)									

Stream 6

Catchment Descriptors (from FEH CD-ROM)

Grid Reference:	264012 372157

AREA	0.56km^2
BFIHOST	0.17
SPRHOST	37.06
URBEXT 1990	0.00
URBEXT 2000	0.00
FARL	0.0152
PROPWET	0.59
SAAR	1338mm
DPSBAR	245.1m/km
DPLBAR	1.35km

Qmed Estimate

Catchment Descriptor Qmed Estimate:	0.549m^3/s
Donor Adjustment or Catchment Descriptors?	CD
Donor Station (where applicable):	N/A
Final Qmed Estimate:	0.549m^3/s

Growth Curve

Method: Pooling Group (minimum 500 years in line with current FEH recommendations)

Curve Distribution: **GL**

Return Period (yrs)	2	5	10	25	50	100	200	500	1000
Scaling Factor	1.000	1.357	1.624	2.019	2.367	2.770	3.238	3.978	4.649

Final Flow Estimates

Return Period (yrs)	2	5	10	25	50	100	200	500	1000
WINFAP (Flow m^3/s)	0.549	0.754	0.891	1.109	1.300	1.521	1.778	2.184	2.552
ReFH	0.43	0.59	0.71	0.87	1.01	1.16	1.31	1.52	1.76

(Flow m^3/s)									

Stream 7

Catchment Descriptors (from FEH CD-ROM)

Grid Reference:	264512 372369

AREA	0.40km^2
BFIHOST	0.17
SPRHOST	37.06
URBEXT 1990	0.00
URBEXT 2000	0.00
FARL	0.0152
PROPWET	0.59
SAAR	1338mm
DPSBAR	245.1m/km
DPLBAR	1.35km

Qmed Estimate

Catchment Descriptor Qmed Estimate:	0.412m^3/s
Donor Adjustment or Catchment Descriptors?	CD
Donor Station (where applicable):	N/A
Final Qmed Estimate:	0.412m^3/s

Growth Curve

Method: Pooling Group (minimum 500 years in line with current FEH recommendations)

Curve Distribution: **GL**

Return Period (yrs)	2	5	10	25	50	100	200	500	1000
Scaling Factor	1.000	1.357	1.623	2.019	2.367	2.769	3.237	3.977	4.648

Final Flow Estimates

Return Period (yrs)	2	5	10	25	50	100	200	500	1000
WINFAP (Flow m^3/s)	0.412	0.559	0.669	0.832	0.976	1.142	1.335	1.640	1.916
ReFH	0.31	0.42	0.51	0.63	0.72	0.83	0.94	1.09	1.26

(Flow m^3/s)									

Stream 8

Catchment Descriptors (from FEH CD-ROM)

Grid Reference:	264976 372569

AREA	0.30km^2
BFIHOST	0.17
SPRHOST	37.06
URBEXT 1990	0.00
URBEXT 2000	0.00
FARL	0.0152
PROPWET	0.59
SAAR	1338mm
DPSBAR	245.1m/km
DPLBAR	1.35km

Qmed Estimate

Catchment Descriptor Qmed Estimate:	0.323m^3/s
Donor Adjustment or Catchment Descriptors?	CD
Donor Station (where applicable):	N/A
Final Qmed Estimate:	0.323m^3/s

Growth Curve

Method: Pooling Group (minimum 500 years in line with current FEH recommendations)

Curve Distribution: **GL**

Return Period (yrs)	2	5	10	25	50	100	200	500	1000
Scaling Factor	1.000	1.357	1.623	2.019	2.367	2.769	3.237	3.977	4.647

Final Flow Estimates

Return Period (yrs)	2	5	10	25	50	100	200	500	1000
WINFAP (Flow m^3/s)	0.323	0.438	0.524	0.652	0.764	0.894	1.045	1.284	1.500
ReFH (Flow m^3/s)	0.23	0.32	0.38	0.47	0.54	0.62	0.70	0.82	0.95

Flood estimation calculation record

Introduction

This document is a supporting document to the Environment Agency's flood estimation guidelines. It provides a record of the calculations and decisions made during flood estimation. It will often be complemented by more general hydrological information given in a project report. The information given here should enable the work to be reproduced in the future. This version of the record is for studies where flood estimates are needed at multiple locations.

Approval

	Signature	Name and qualifications	For Environment Agency staff: Competence level (see below)
Calculations prepared by:		Petra Urquhart Irvine BSc (Hons)	
Calculations checked by:		Rob Williams (BEng (Hons), IEng, MICE)	
Calculations approved by:			

Environment Agency competence levels are covered in Section 2.1 of the flood estimation guidelines:

- Level 1 – Hydrologist with minimum approved experience in flood estimation
- Level 2 – Senior Hydrologist
- Level 3 – Senior Hydrologist with extensive experience of flood estimation

ABBREVIATIONS

AM	Annual Maximum
AREA	Catchment area (km^2)
BFI	Base Flow Index
BFIHOST	Base Flow Index derived using the HOST soil classification
CFMP	Catchment Flood Management Plan
CPRE	Council for the Protection of Rural England
FARL	FEH index of flood attenuation due to reservoirs and lakes
FEH	Flood Estimation Handbook
FSR	Flood Studies Report
HOST	Hydrology of Soil Types
NRFA	National River Flow Archive
POT	Peaks Over a Threshold
QMED	Median Annual Flood (with return period 2 years)
ReFH	Revitalised Flood Hydrograph method
SAAR	Standard Average Annual Rainfall (mm)
SPR	Standard percentage runoff
SPRHOST	Standard percentage runoff derived using the HOST soil classification
Tp(0)	Time to peak of the instantaneous unit hydrograph
URBAN	Flood Studies Report index of fractional urban extent
URBEXT1990	FEH index of fractional urban extent
URBEXT2000	Revised index of urban extent, measured differently from URBEXT1990
WINFAP-FEH	Windows Frequency Analysis Package – used for FEH statistical method

Method statement

Overview of requirements for flood estimates

Item	Comments
Give an overview which includes: Purpose of study Approx. no. of flood estimates required Peak flows or hydrographs? Range of return periods and locations Approx. time available	Calculation of peak flows and river hydrographs for use in the hydraulic model of Afon Wig, located along the A55. The hydrology and hydraulic model to aid the design of the Proposed Improvement to increase the safety and reduce the risk of flooding to the A55. The culvert that currently carries Stream 5 (Afon Wig) under the A55 will be upsized to increase the capacity of the culvert. Establishing the current base-flow of the stream will allow for suitable design and mitigation measures to be assessed. Return periods to be investigated will be 1% AEP and 0.1% AEP

Overview of catchment

Item	Comments
Brief description of catchment, or reference to section in accompanying report	Small rural catchment with a section currently piped under the A55 before out-falling into an open stream within agricultural fields. Stream 5 is classed as a Main River immediately downstream of the A55 where the stream leaves the culvert into the open stream.

Source of flood peak data

Was the HiFlows UK dataset used? If so, which version? If not, why not? Record any changes made	Yes Version 3.3.4

Gauging stations (flow or level)

(at the sites of flood estimates or nearby at potential donor sites)

Water-course	Station name	Gauging authority number	NRFA number (used in FEH)	Grid reference	Catch-ment area (km²)	Type (rated / ultrasonic / level…)	Start and end of flow record
Seiont	Pebilg Mill (Donor)	NRW	65006	SH 494622	74.4	Velocity Area	1976-2004

Data available at each flow gauging station

Station name	Start and end of data in HiFlows-UK	Update for this study?	Suitable for QMED?	Suitable for pooling?	Data quality check needed?	Other comments on station and flow data quality – e.g. information from HiFlows-UK, trends in flood peaks, outliers.
Peblig Mill	1976-2004	NA	Yes	No	No	No Outliners in rating curve
Give link/reference to any further data quality checks carried out						

Rating equations

Station name	Type of rating e.g. theoretical, empirical; degree of extrapolation	Rating review needed?	Reasons – e.g. availability of recent flow gaugings, amount of scatter in the rating.
Peblig Mill	Degree of extrapolation, well gauged to bankfull	No	Very little scatter observed in ratings
Give link/reference to any rating reviews carried out			

Other data available and how it has been obtained

Type of data	Data relevant to this study?	Data available?	Source of data and licence reference if from EA	Date obtained	Details
Check flow gaugings (if planned to review ratings)					
Historic flood data – give link to historic review if carried out.					
Flow data for events					
Rainfall data for events					
Potential evaporation data					
Results from previous studies (e.g. CFMPs, Strategies)					
Other data or information (e.g. groundwater, tides)					

Initial choice of approach

Is FEH appropriate? (it may not be for very small, heavily urbanised or complex catchments) If not, describe other methods to be used.	FEH is an appropriate method for estimation of flows in this catchment. The catchment is small but FEH Statistical can still be applied.
Outline the conceptual model, addressing questions such as: Where are the main sites of interest? What is likely to cause flooding at those locations? (peak flows, flood volumes, combinations of peaks, groundwater, snowmelt, tides…) Might those locations flood from runoff generated on part of the catchment only, e.g. downstream of a reservoir? Is there a need to consider temporary debris dams that could collapse?	Peak flows are assumed to not cause flooding at this site. Potential flooding if culvert becomes blocked/ collapses. Upsizing culvert can reduce flood risks but consequences need to be investigated
Any unusual catchment features to take into account? e.g. highly permeable – avoid ReFH if BFIHOST>0.65, use permeable catchment adjustment for statistical method if SPRHOST<20% highly urbanised – avoid ReFH if URBEXT1990>0.125; consider FEH Statistical or other alternatives pumped watercourse – consider lowland catchment	Small catchment area. Stream is culverted under the A55.

version of rainfall-runoff method major reservoir influence (FARL<0.90) – consider flood routing extensive floodplain storage – consider choice of method carefully	
Initial choice of method(s) and reasons Will the catchment be split into subcatchments? If so, how?	The FEH statistical method is preferred. WINFAP software produced a higher peak flow. ReFH method carried out as a check.
Software to be used (with version numbers)	FEH CD-ROM V3[1] WINFAP-FEH v3[2] / ReFH 2

[1] FEH CD-ROM v2.0 © NERC (CEH). © Crown copyright. © AA. 2006. All rights reserved.
[2] WINFAP-FEH v2.0.2 © Wallingford HydroSolutions Limited and NERC (CEH) 2006.

Locations where flood estimates required

The table below lists the locations of subject sites. The site codes listed below are used in all subsequent tables to save space.

Summary of subject sites

Site code	Watercourse	Site	Easting	Northing	AREA on FEH CD-ROM (km^2)	Revised AREA if altered
Wig	Ordinary watercourse then Main River downstream of A55	Afon Wig	263400	372000	2.30	
Reasons for choosing above locations		Upsizing of culvert proposed for improvement works				

Important catchment descriptors at each subject site (incorporating any changes made)

Site code	FARL	PROPWET	BFIHOST	DPLBAR (km)	DPSBAR (m/km)	SAAR (mm)	SPRHOST	URBEXT	FPEXT
Wig	1.000	0.59	0.485	2.09	251.5	1467	39.4	0.000	0.0128

Checking catchment descriptors

Record how catchment boundary was checked and describe any changes (refer to maps if needed)	FEH Catchment areas compared to that derived from WFD catchments and checked against OS 5m contours.
Record how other catchment descriptors (especially soils) were checked and describe any changes. Include before/after table if necessary.	SAAR checked against annual rainfall map of Britain and was found to be correct. BFIHOST and SPRHOST were checked by re-calculation using a soils map and were found to be similar to the values given by the FEH CD-ROM; therefore they have not been altered. URBEXT was checked against OS maps and GIS software and was found to be correct an reflects the rural characteristic of the catchment.
Source of URBEXT	URBEXT2000
Method for updating of URBEXT	

Statistical method

Overview of estimation of QMED at each subject site

Site code	Method	Initial estimate of QMED (m^3/s)	Data transfer				Final estimate of QMED (m^3/s)
			NRFA numbers for donor sites used (see 3.3)	Distance between centroids d_{ij} (km)	Power term, a	Moderated QMED adjustment factor, $(A/B)^a$	
Wig	DT	2.281	1	12.14	0.36	1.053	2.392
Are the values of QMED consistent, for example at successive points along the watercourse and at confluences?							

Notes
Methods: AM – Annual maxima; POT – Peaks over threshold; DT – Data transfer; CD – Catchment descriptors alone.
When QMED is estimated from POT data, it should also be adjusted for climatic variation. Details should be added below.
When QMED is estimated from catchment descriptors, the revised 2008 equation from Science Report SC050050 should be used. If the original FEH equation has been used, say so and give the reason why.
The data transfer procedure is the revised one from Science Report SC050050. The QMED adjustment factor A/B for each donor site is given in Table 3.3. This is moderated using the power term, a, which is a function of the distance between the centroids of the subject catchment and the donor catchment. The final estimate of QMED is $(A/B)^a$ times the initial estimate from catchment descriptors.
If more than one donor has been used, give the weights used in the averaging.

Search for donor sites for QMED

Comment on potential donor sites Mention: Number of potential donor sites available Distances from subject site Similarity in terms of AREA, BFIHOST, FARL and other catchment descriptors Quality of flood peak data Include a map if necessary. Note that donor catchments should usually be rural.	From pooling group 10 donor stations were considered suitable as donors. Seiont@ Peblig Mill (65006) was chosen as donor due to close proximity to Afon Wig.

Donor sites chosen and QMED adjustment factors

NRFA no.	Reasons for choosing or rejecting	Method (AM or POT)	Adjust-ment for climatic variation?	QMED from flow data (A)	QMED from catchment descriptors (B)	Adjust-ment ratio (A/B)
65006	This station was chosen as it has the closest catchment centroid distance (10.55km). AREA and SAAR is not very similar, but it is the best out of the available donor stations available. Flows are gauged to within 12% of QMED and there is no bypassing of the channel. The geometrical weighting given to this station is 0.4.	AM	N/A	46.243	40.004	1.15596

NRFA no.	Reasons for choosing or rejecting	Method (AM or POT)	Adjust-ment for climatic variation?	QMED from flow data (A)	QMED from catchment descriptors (B)	Adjust-ment ratio (A/B)

Derivation of pooling groups

The composition of the pooling groups is given in the Annex. Several subject sites may use the same pooling group.

Target return period (years) for all pooling groups			100	
Name of group	Site code for which group derived	Changes made to default pooling group, with reasons Note also any sites that were investigated but retained in the group.	Distribution and reason for choice	Parameters (before urban adjustment) Note any permeable catchment adjustments
		(States number of years of original pooling group) Sites disregarded due to no suitable for pooling group or discordancy	GL	none
Note: the revised procedures from Science Report SC050050 (2008).				

Derivation of flood growth curves at subject sites

Site code	Method: SS – Single site P – Pooled J – Joint analysis	If P or J, name of pooling group (0)	If SS, distribution used and reason for choice If J, details of averaging	If SS, parameters of distribution (location, scale and shape)	Growth factor for 100-year return period
Wig	P				2.933
Note: the revised procedures from Science Report SC050050 (2008).					

Flood estimates from the statistical method

Site code	Flood peak (m^3/s) for the following return periods (in years)								
	2	5	10	25	50	100	200	500	1000
Wig	2.580	3.546	4.284	5.398	6.397	7.569	8.953	11.180	13.229

Revitalised flood hydrograph (ReFH) method

Parameters for ReFH model

Note: If parameters are estimated from catchment descriptors, they are easily reproducible so it is not essential to enter them in the table.

Site code	Method: OPT: Optimisation BR: Baseflow recession fitting CD: Catchment descriptors DT: Data transfer (give details)	Tp (hours) Time to peak	C_{max} (mm) Maximum storage capacity	BL (hours) Baseflow lag	BR Baseflow recharge
Wig	CD	1.1	343.46	31.43	1.45

Brief description of any flood event analysis carried out (further details should be given below or in a project report)	

Design events for ReFH method

Site code	Urban or rural	Season of design event (summer or winter)	Storm duration (hours)	Storm area for ARF (if not catchment area)
Wig	rural	Winter	2.75	2.56km^2

Are the storm durations likely to be changed in the next stage of the study, e.g. by optimisation within a hydraulic model?	No

Flood estimates from the ReFH method

Site code	Flood peak (m^3/s) or volumes (m^3) for the following return periods (in years)								
	2	5	10	25	50	100	200	500	1000
Wig	1.87	2.54	3.05	3.76	4.34	4.95	5.59	6.48	7.50

FEH rainfall-runoff method

Parameters for FEH rainfall-runoff model

Methods: FEA : Flood event analysis
LAG : Catchment lag
DT : Catchment descriptors with data transfer from donor catchment
CD : Catchment descriptors alone
BFI : SPR derived from baseflow index calculated from flow data

Site code	Rural (R) or urban (U)	Tp(0): method	Tp(0): value (hours)	SPR: method	SPR: value (%)	BF: method	BF: value (m^3/s)	If DT, numbers of donor sites used (see Section 5.2) and reasons

Donor sites for FEH rainfall-runoff parameters

No.	Watercourse	Station	Tp(0) from data (A)	Tp(0) from CDs (B)	Adjustment ratio for Tp(0) (A/B)	SPR from data (C)	SPR from CDs (D)	Adjust-ment ratio for SPR (C/D)
1								
2								

Inputs to and outputs from FEH rainfall-runoff model

Site code	Storm duration (hours)	Storm area for ARF (if not catchment area)	Flood peaks (m^3/s) or volumes (m^3) for the following return periods (in years)							
			2							
Are the storm durations likely to be changed in the next stage of the study, e.g. by optimisation within a hydraulic model?										

Small catchment methods

This section records any estimates of design flows for small catchments using methods other than the FEH. In this case, the Institute of Hydrology Report 124 method has been used as an alternative. Other methods can be added or substituted if needed.

Parameters for IH Report 124 method

Site code	Area (km^2)	$SAAR_{4170}$ (mm)	URBAN (fraction)	Fraction of catchment covered by WRAP class (soil types given on Figure I 4.18 in FSR Volume 5)					Hydrometric area
				1	2	3	4	5	

Flood estimates from the IH Report 124 method at each subject site

Site code	Flood peak (m^3/s) for the following return periods (in years)								

Discussion and summary of results

Comparison of results from different methods

This table compares peak flows from various methods with those from the FEH Statistical method at example sites for two key return periods. Blank cells indicate that results for a particular site were not calculated using that method.

Site code	Ratio of peak flow to FEH Statistical peak					
	Return period 2 years			Return period 100 years		
	ReFH	WINFAP (statistical)		ReFH	WINFAP (statistical)	
Wig flows	1.87	2.580		4.95	7.569	
Ratio	1.38			1.52		

Final choice of method

Choice of method and reasons – include reference to type of study, nature of catchment and type of data available.	Statistical method was the final method of choice as the peak flow estimates produced represent a more accurate peak flow for the catchment when compared to similar sized nearby catchments.

Assumptions, limitations and uncertainty

List the main assumptions made (specific to this study)	Assumed that the catchment is entirely rural, that the catchment is largely unchanged, water not lost in field drainage (kept within the stream system)
Discuss any particular limitations, e.g. applying methods outside the range of catchment types or return periods for which they were developed	Small catchment size resulted in few possible suitable donor stations of similar catchment descriptors.
Give what information you can on uncertainty in the results – e.g. confidence limits for the QMED estimates using FEH 3 12.5 or the factorial standard error from Science Report SC050050 (2008).	Qmed= 2.580 Confidence limits of 95% Lower= 1.26 Upper= 5.26
Comment on the suitability of the results for future studies, e.g. at nearby locations or for different purposes.	A reasonable suitability due to knowledge of studies of nearby catchments of similar characteristics.
Give any other comments on the study, for example suggestions for additional work.	Further works into field drainage (water lost to system, water gained into the system from field)

Checks

Are the results consistent, for example at confluences?	
What do the results imply regarding the return periods of floods during the period of record?	

What is the 100-year growth factor? Is this realistic? (The guidance suggests a typical range of 2.1 to 4.0)	2.933- this figure lies within the typical range and is considered to be realistic
If 1000-year flows have been derived, what is the range of ratios for 1000-year flow over 100-year flow?	1.75 (FEH statistical 1000yr/ 100yr)
What range of specific runoffs (l/s/ha) do the results equate to? Are there any inconsistencies?	Catchment area= 2.56km^2 =256ha 1 in 100 year peak (FEH) = 7.569m3/s = 7569 l/s Runoff equates to 29.5664 l/s/ha
How do the results compare with those of other studies? Explain any differences and conclude which results should be preferred.	
Are the results compatible with the longer-term flood history?	
Describe any other checks on the results	

Final results

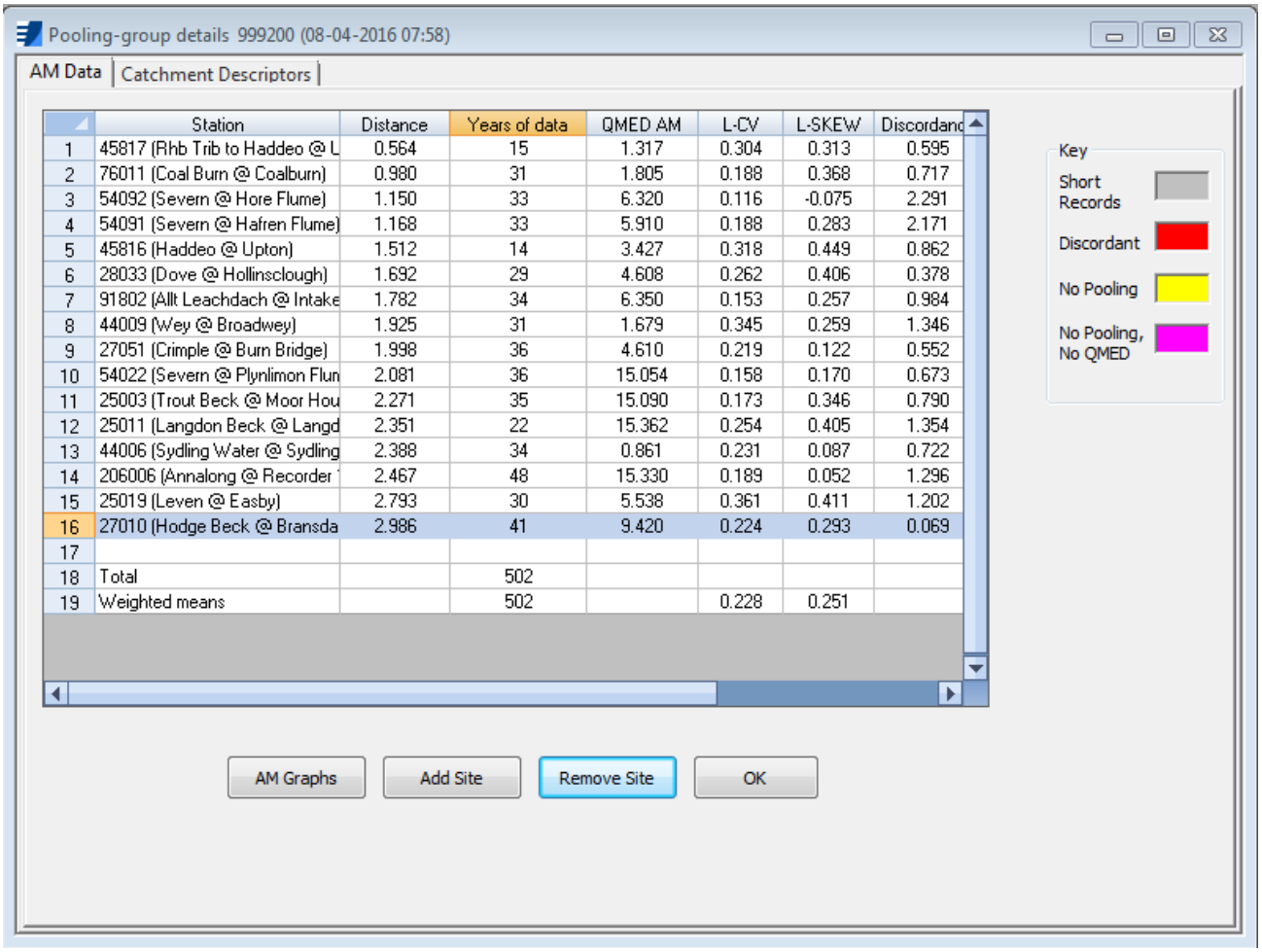
Site code	Flood peak (m^3/s) or volume (m^3) for the following return periods (in years)								
	2	5	10	25	50	100	200	500	1000
Wig	2.580	3.546	4.284	5.398	6.397	7.569	8.953	11.180	13.229

If flood hydrographs are needed for the next stage of the study, where are they provided? (e.g. give filename of spreadsheet, name of ISIS model, or reference to table below)	

Annex - supporting information

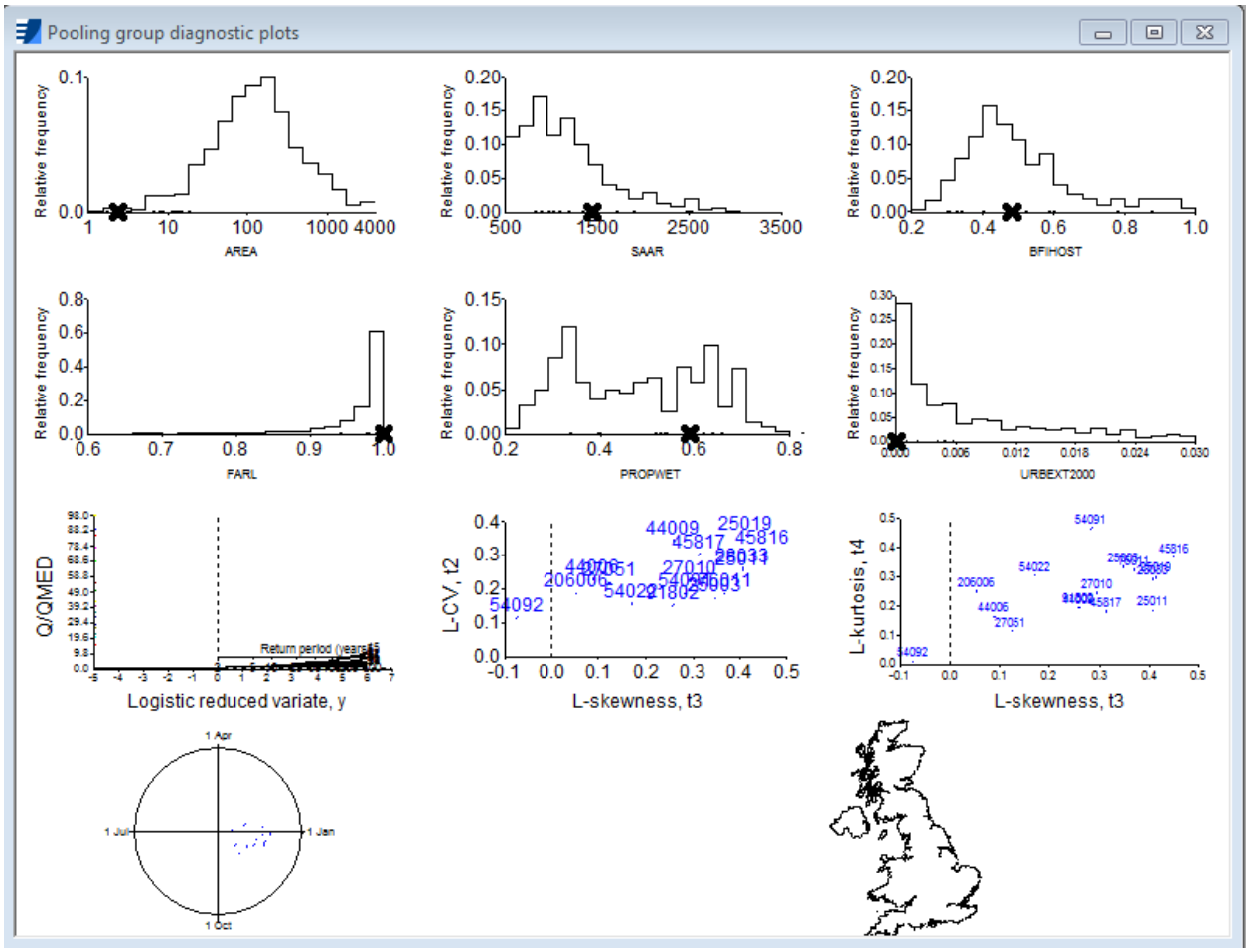
Pooling group composition

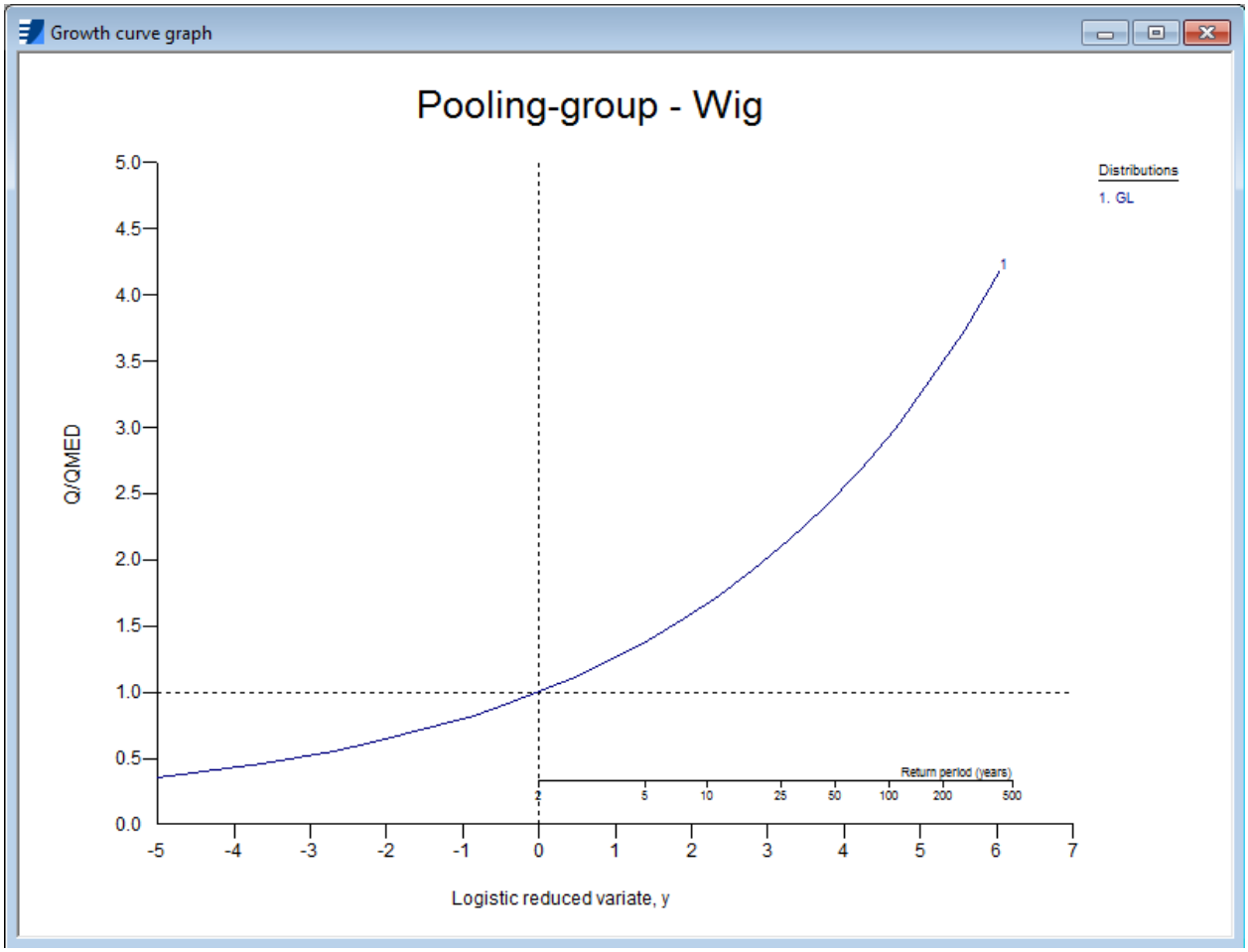
Initial pooling group included 69 sites giving a total record length of 2001 years (default record length of 500 years edited to 2000 years as so many sites unsuitable for pooling).
Final pooling group included 16 sites to give a total record length of 502 years.

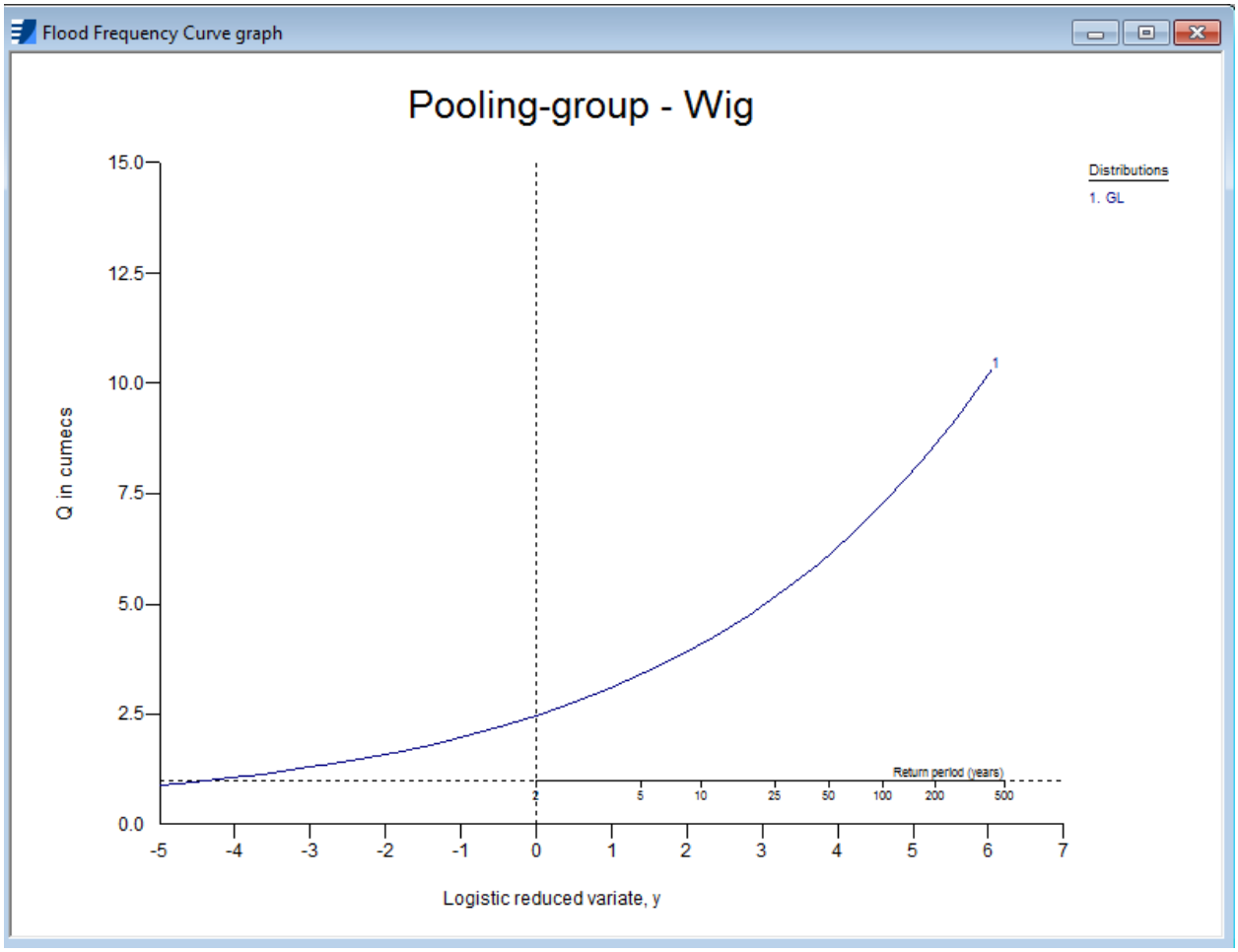


	Station	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordanc
1	45817 (Rhb Trib to Haddeo @ L	0.564	15	1.317	0.304	0.313	0.595
2	76011 (Coal Burn @ Coalburn)	0.980	31	1.805	0.188	0.368	0.717
3	54092 (Severn @ Hore Flume)	1.150	33	6.320	0.116	-0.075	2.291
4	54091 (Severn @ Hafren Flume)	1.168	33	5.910	0.188	0.283	2.171
5	45816 (Haddeo @ Upton)	1.512	14	3.427	0.318	0.449	0.862
6	28033 (Dove @ Hollinsclough)	1.692	29	4.608	0.262	0.406	0.378
7	91802 (Allt Leachdach @ Intake	1.782	34	6.350	0.153	0.257	0.984
8	44009 (Wey @ Broadwey)	1.925	31	1.679	0.345	0.259	1.346
9	27051 (Crimple @ Burn Bridge)	1.998	36	4.610	0.219	0.122	0.552
10	54022 (Severn @ Plynlimon Flun	2.081	36	15.054	0.158	0.170	0.673
11	25003 (Trout Beck @ Moor Hou	2.271	35	15.090	0.173	0.346	0.790
12	25011 (Langdon Beck @ Langd	2.351	22	15.362	0.254	0.405	1.354
13	44006 (Sydling Water @ Sydling	2.388	34	0.861	0.231	0.087	0.722
14	206006 (Annalong @ Recorder	2.467	48	15.330	0.189	0.052	1.296
15	25019 (Leven @ Easby)	2.793	30	5.538	0.361	0.411	1.202
16	27010 (Hodge Beck @ Bransda	2.986	41	9.420	0.224	0.293	0.069
17							
18	Total		502				
19	Weighted means		502		0.228	0.251	

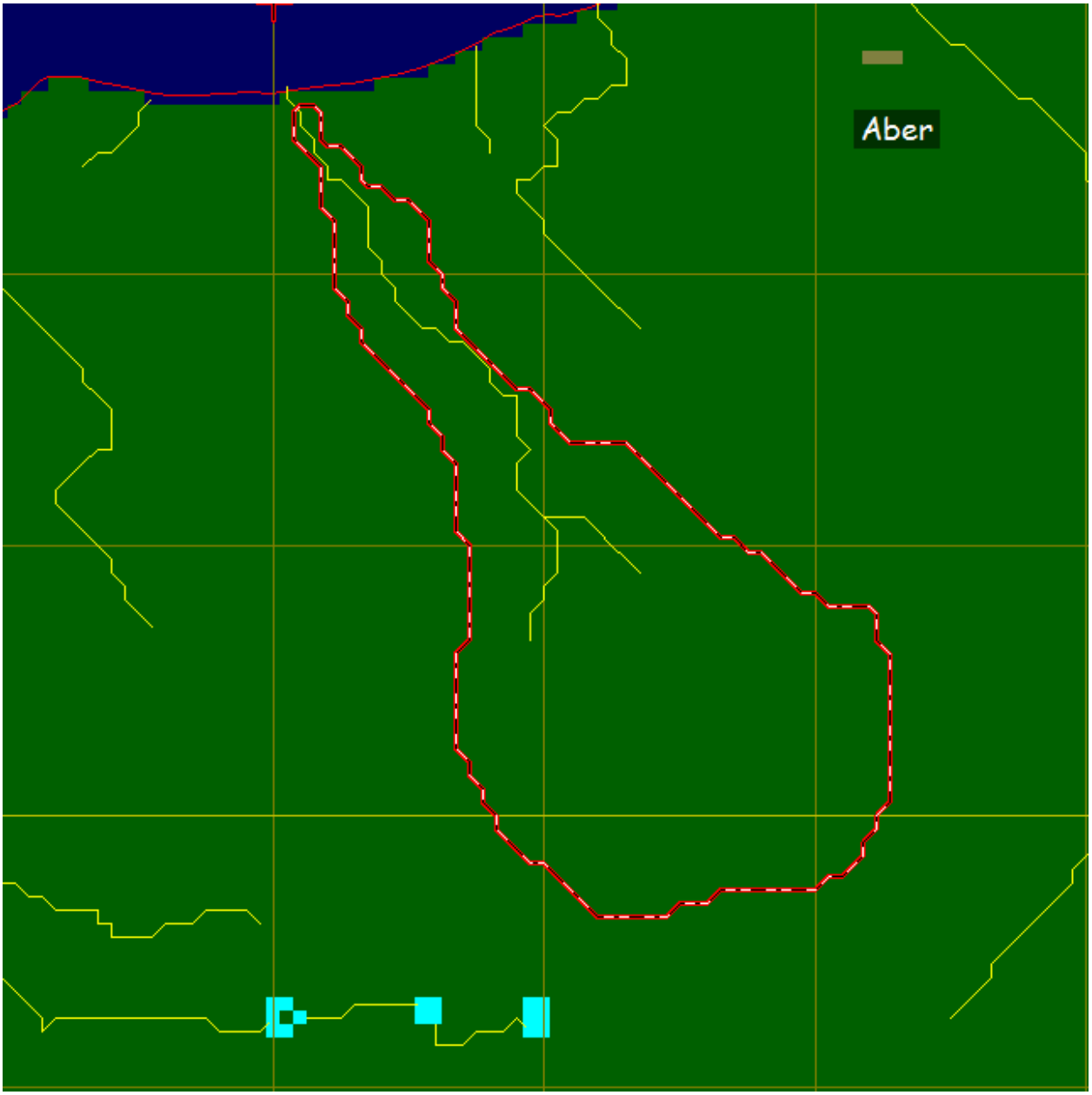
Additional supporting information



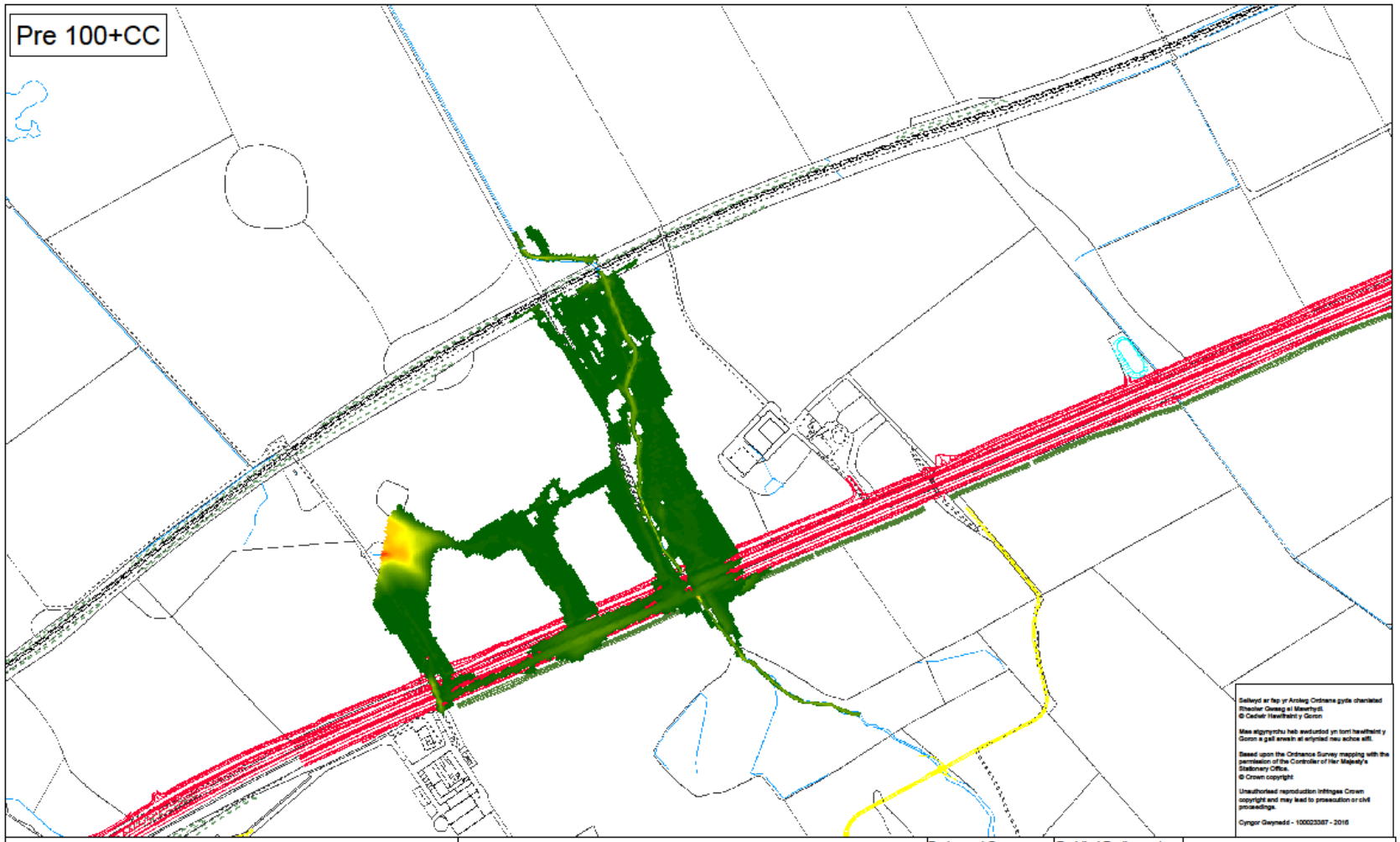

Growth curve graph
Pooling-group - Wig
Distributions
1. GL
Q/QMED
Logistic reduced variate, y
Return period (years)
2
5
10
25
50
100
200
500
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
-5
-4
-3
-2
-1
0
1
2
3
4
5
6
7


Flood Frequency Curve graph
Pooling-group - Wig
Distributions
1. GL
Q in cumecs
15.0
12.5
10.0
7.5
5.0
2.5
0.0
-5
-4
-3
-2
-1
0
1
2
3
4
5
6
7
Logistic reduced variate, y
Return period (years)
2
5
10
25
50
100
200
500
1

Catchment outline (FEH 3 CD ROM)



Appendix P- Hydraulic Assessment- Pre 1 in 100+CC



Teitl y Prosiect/ Project Title

A55(T) Abergwyngregyn - Tai'r Meibion Improvement

Teitl y Cynllun/ Drawing Title

Hydraulic Model Outputs-
Pre 1 in 100 +CC Scenario

Darlunwyd Gan: Drawn By: PUI

Dyddiad Darlunwyd: Date Drawn: 07/07/16

Gwiriwyd Gan: Checked By: RW

Dyddiad Gwiriwyd: Date Checked: 07/07/16

Taflen: Sheet: 1 of 1

Graddfeydd: Scales:

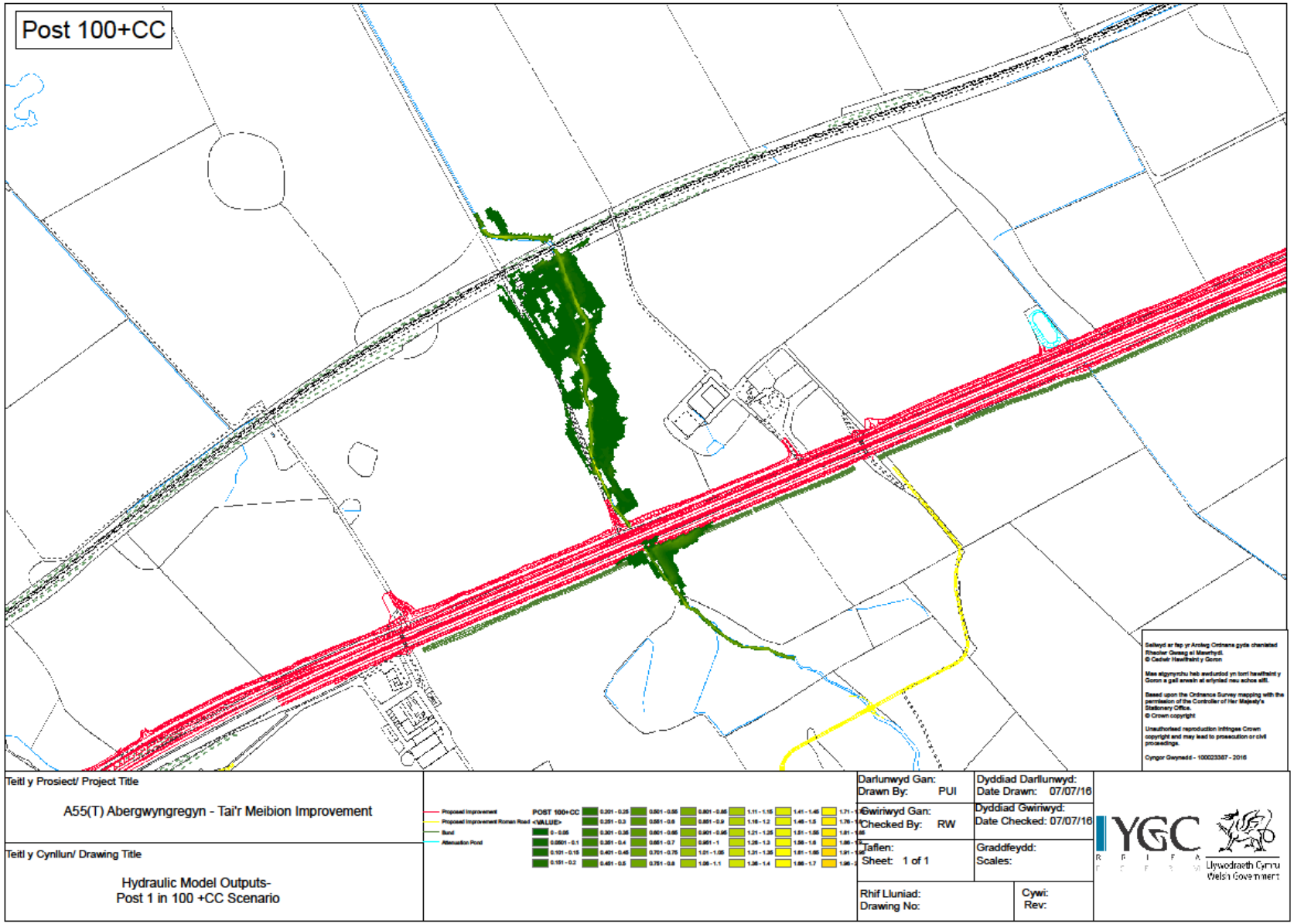
Rhif Lluniad: Drawing No:

Cywi: Rev:

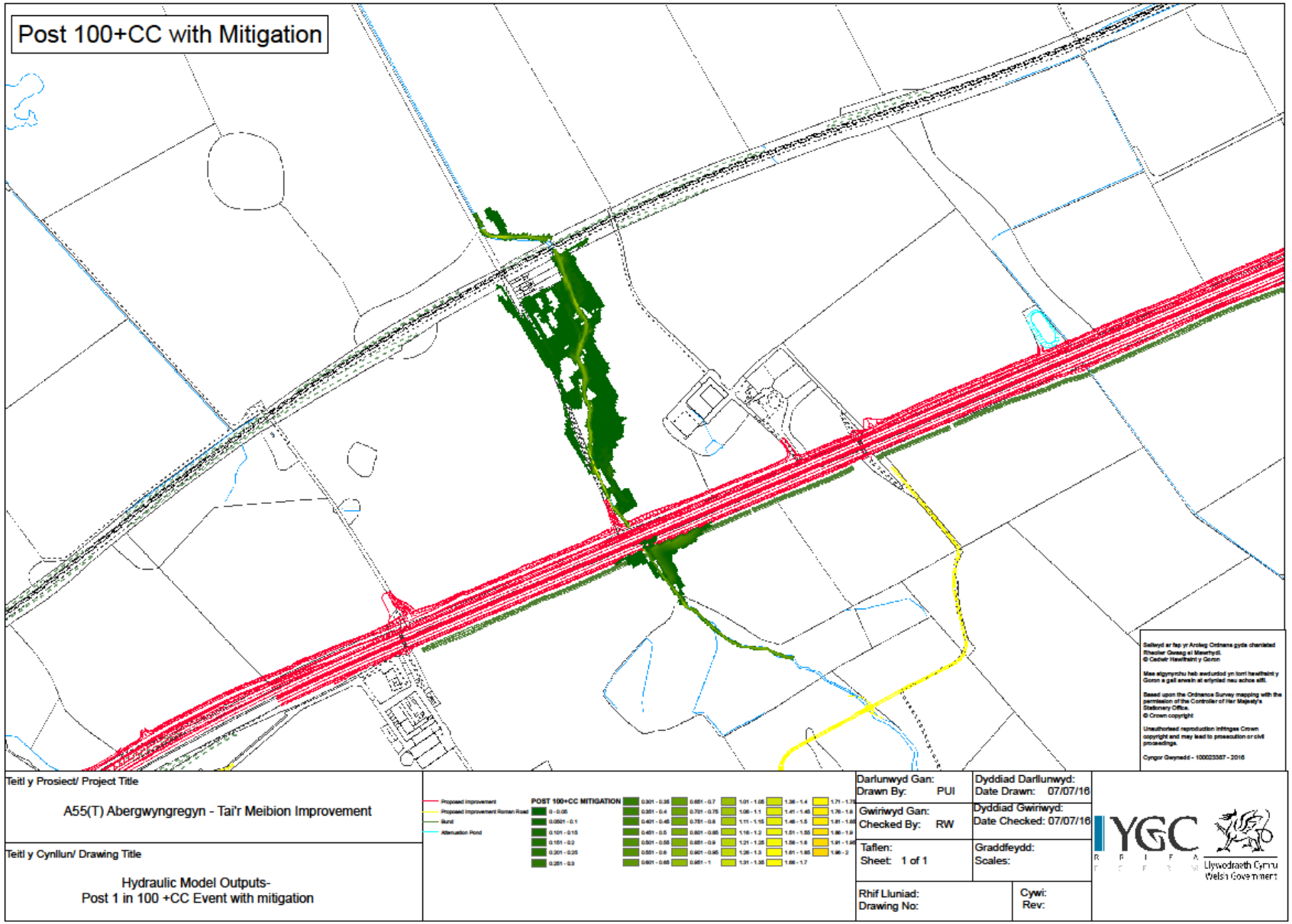
YGC

Llywodraeth Cymru
Welsh Government

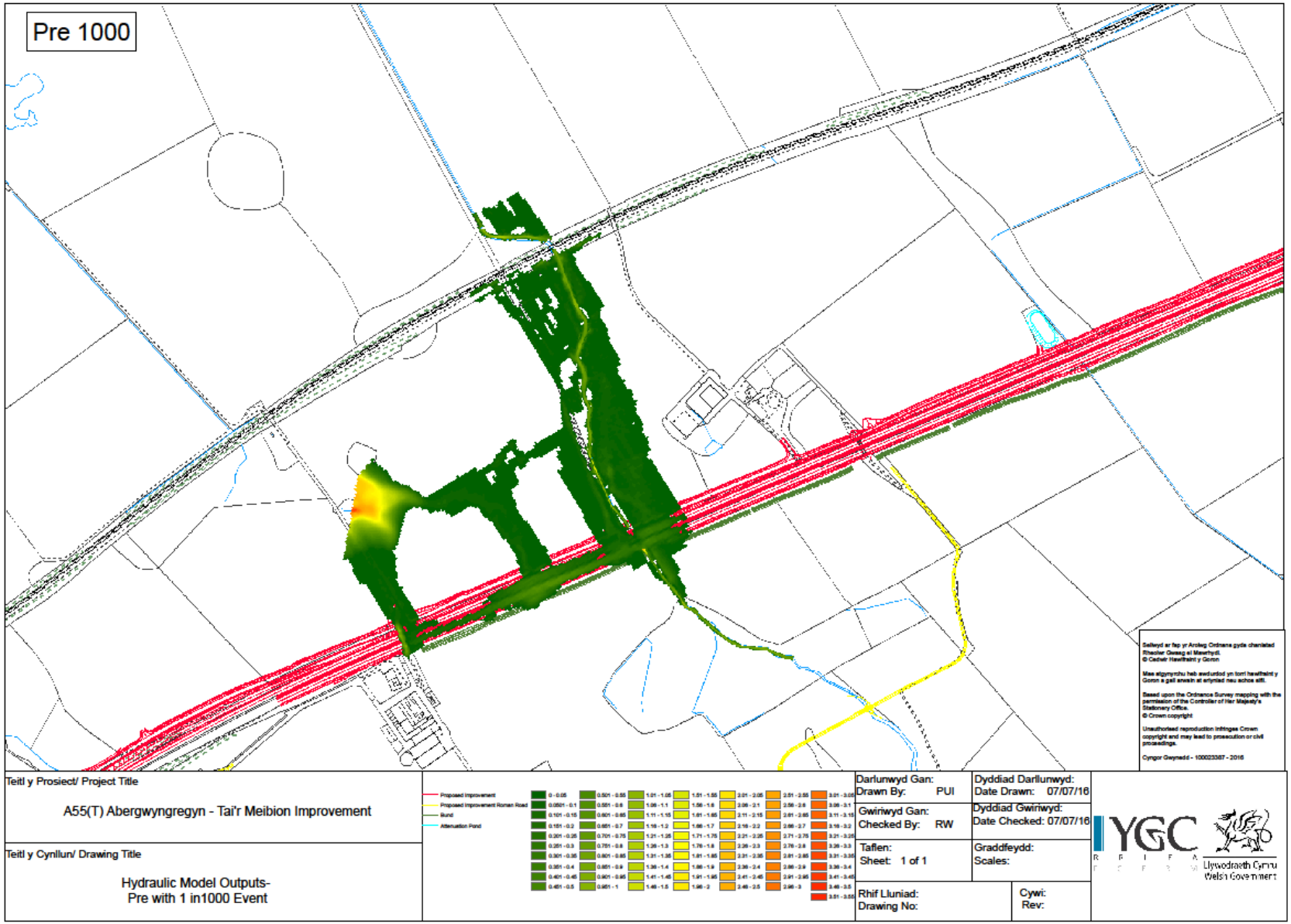
Appendix Q- Hydraulic Assessment- Post 1 in 100+CC



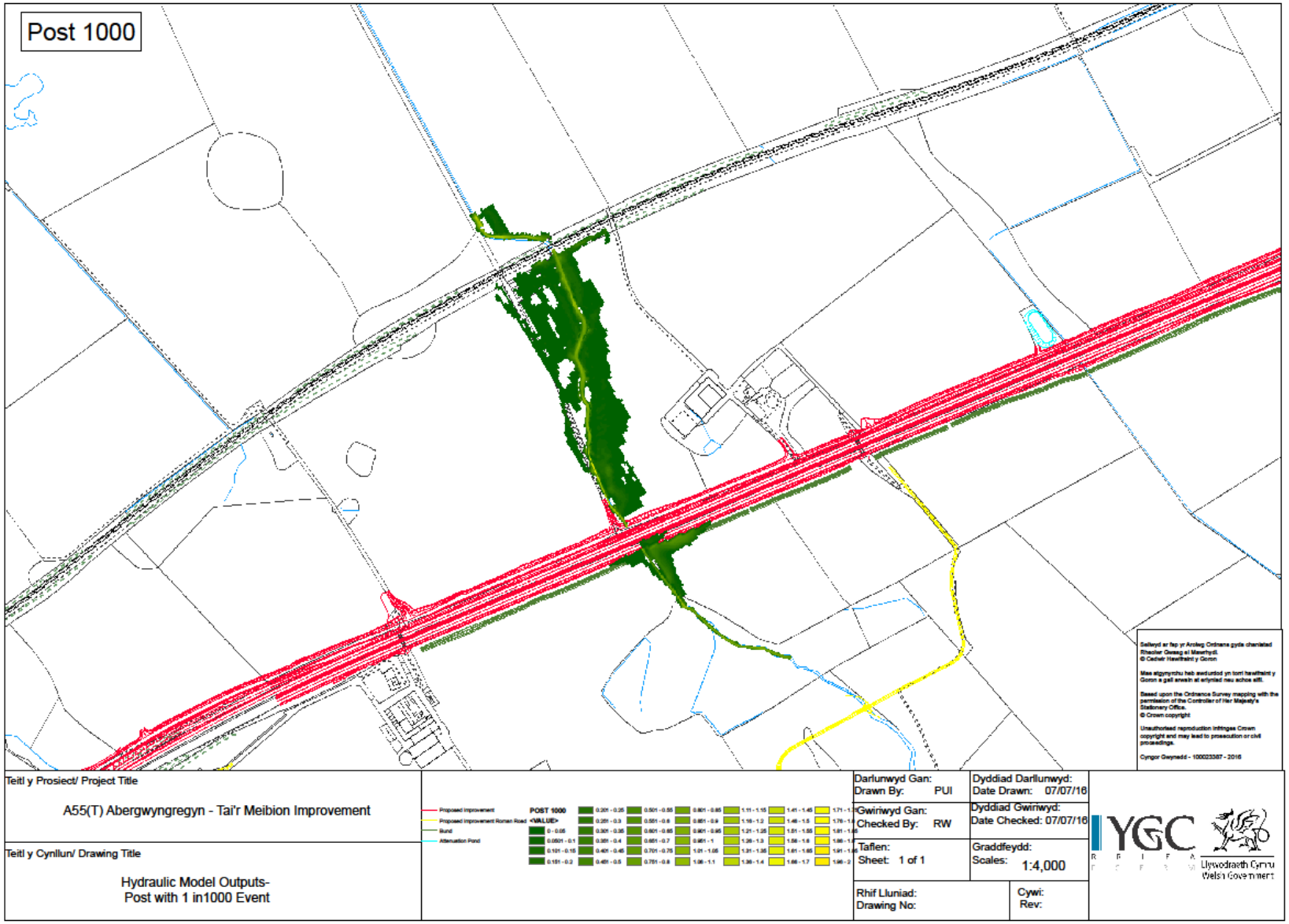
Appendix R- Hydraulic Assessment- Post 1 in 100+CC with mitigation



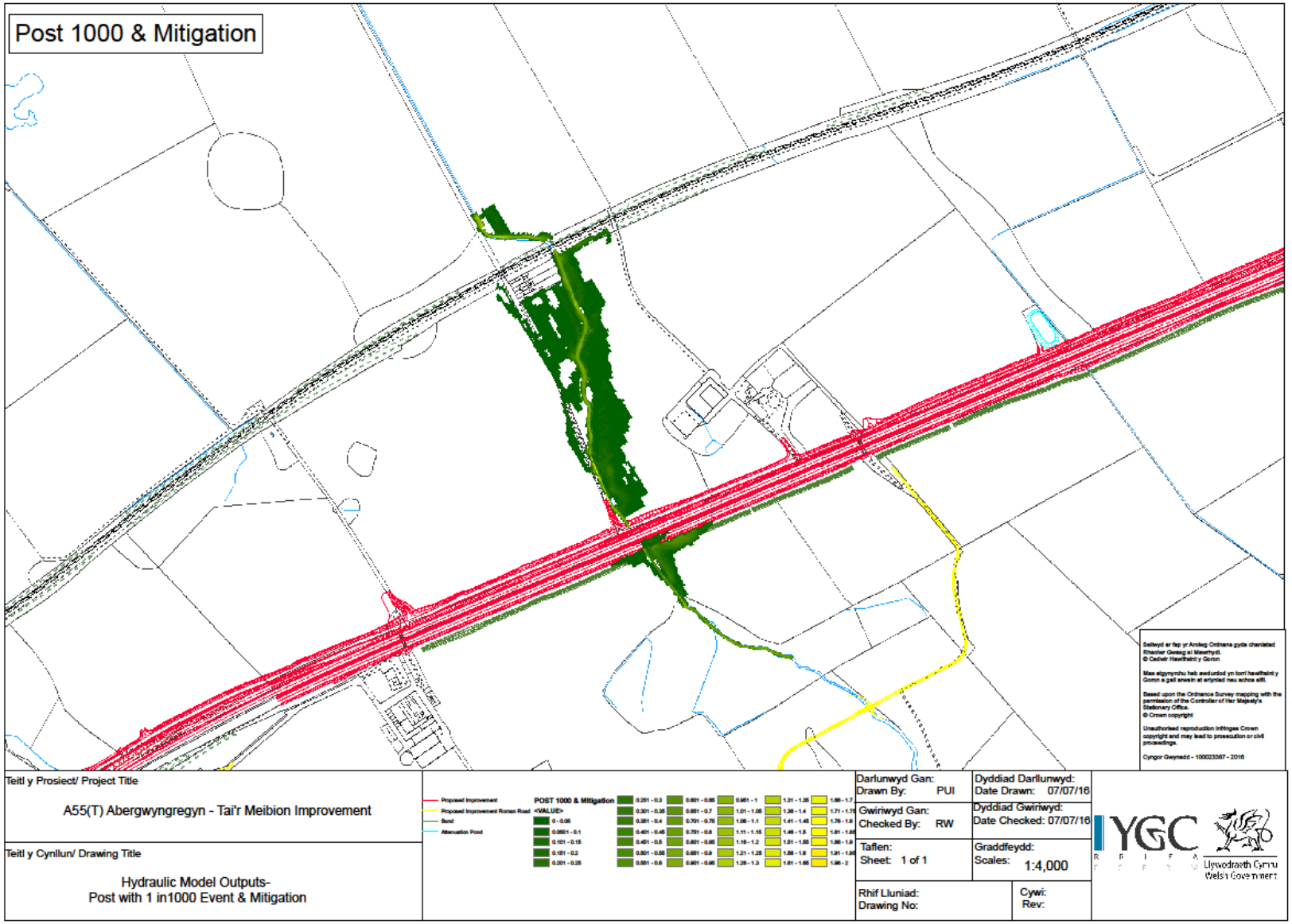
Appendix S- Hydraulic Assessment- 1 in 1000 Pre



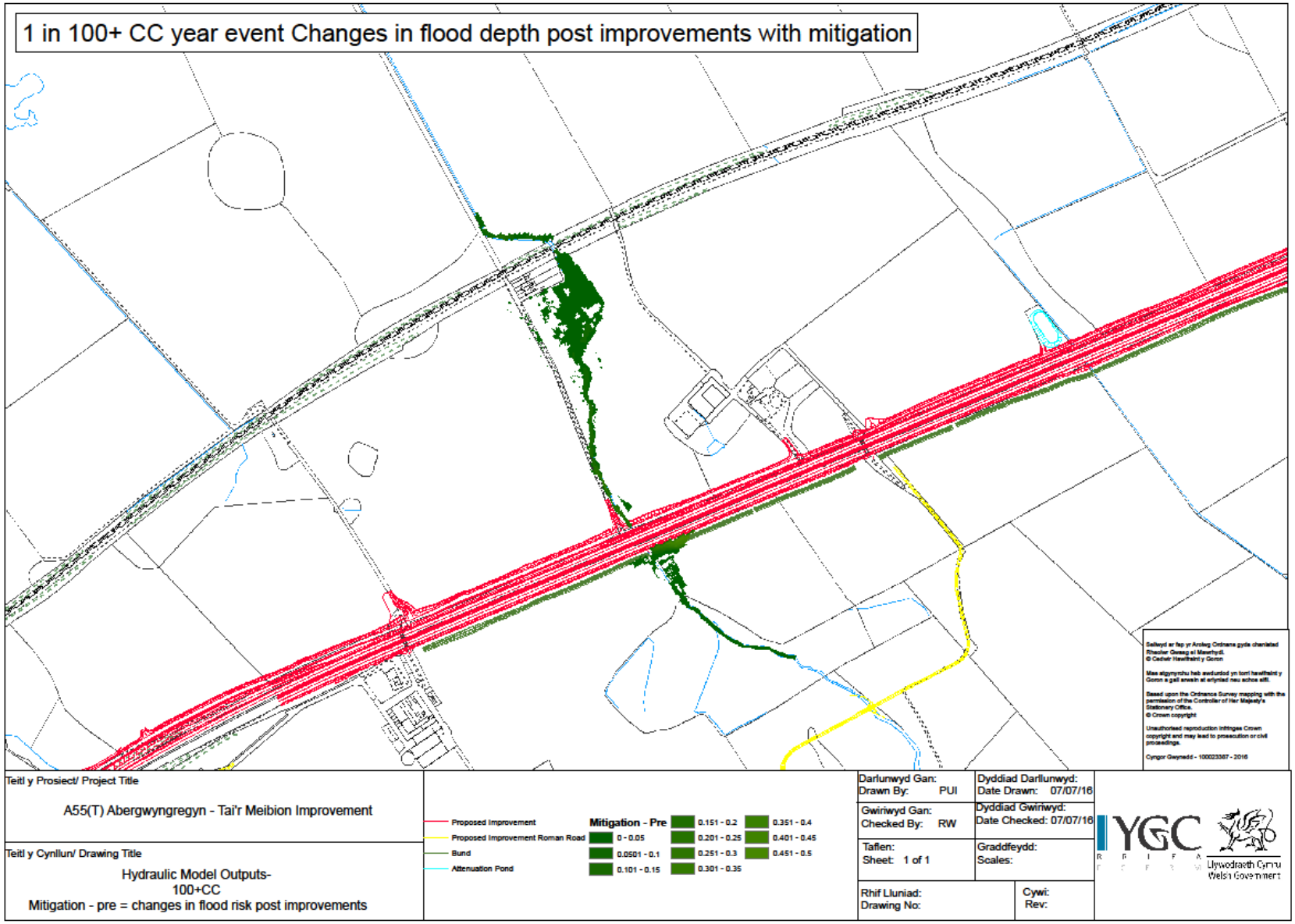
Appendix T- Hydraulic Assessment- 1 in 1000 Post



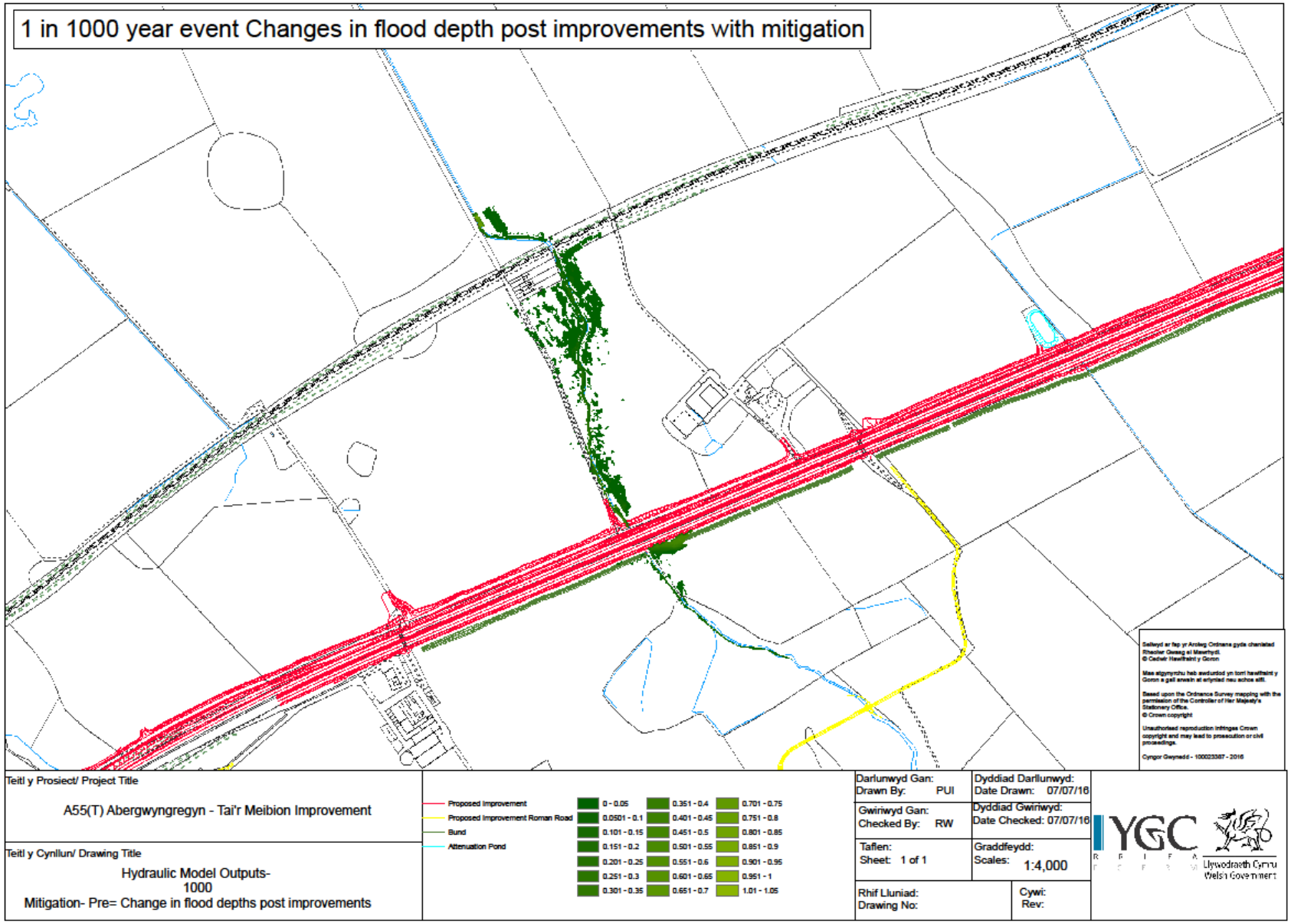
Appendix U- Hydraulic Assessment- 1 in 1000 Post with mitigation



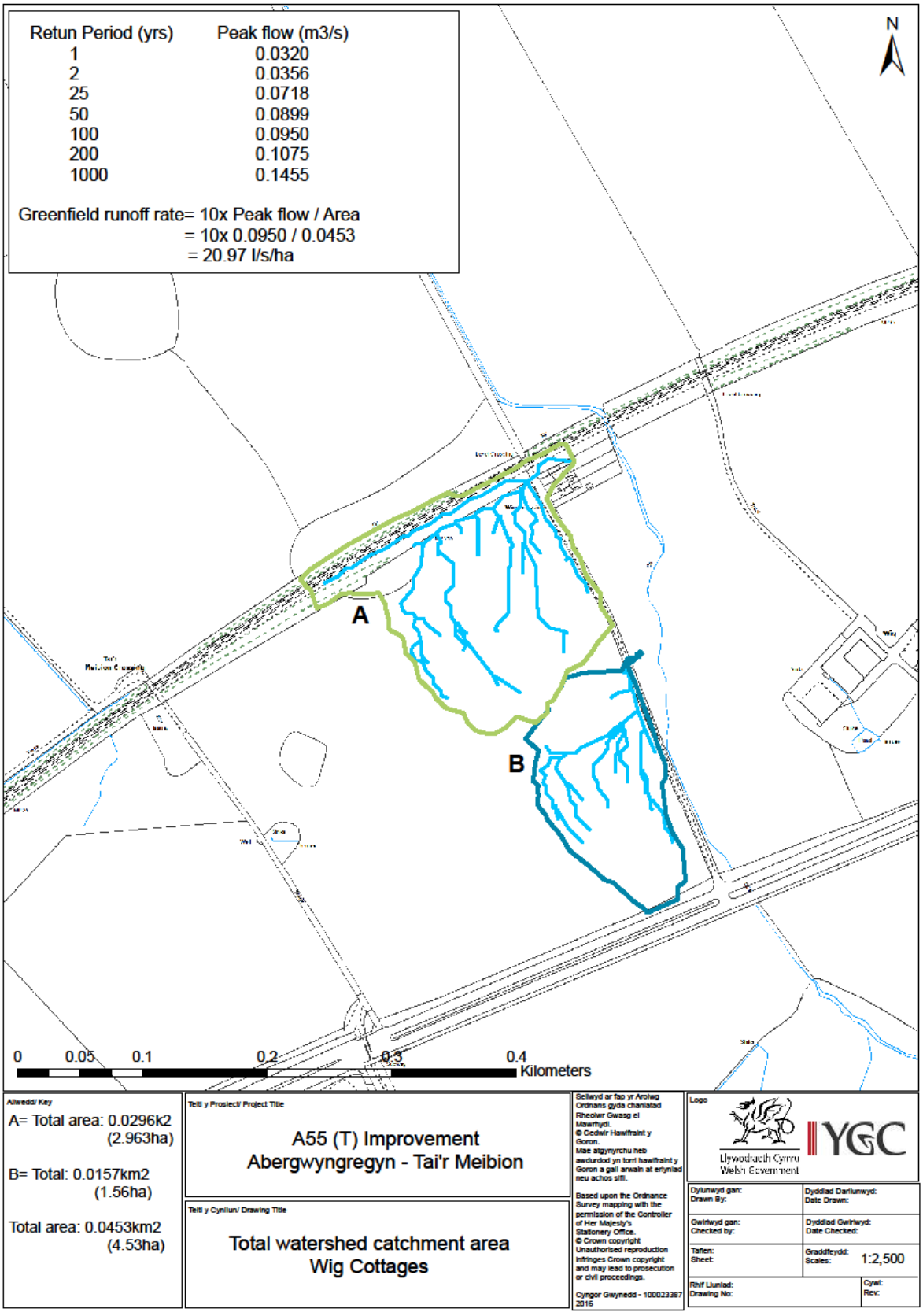
Appendix V- Hydraulic Assessment- Post improvements changes to flood risk 1 in 100+CC



Appendix W- Hydraulic Assessment- change in flood depths Post improvements and mitigation measures 1 in 1000



Appendix X- Watershed Analysis Wig Crossing Cottages using LiDAR data.



Appendix Y- ReFH plot scale method- adjusted catchment size following guidance from the SuDS manual

Table Y1 Catchment Descriptors from FEH CD ROM

Catchment Descriptor	Value
AREA	0.0453km2
BFIHOST	0.48
DPLBAR	2.29
DPSBAR	253.8
PROPWET	0.59
Tp (Hrs)	1
BL	30.517

Table Y2 Runoff figures derived from ReFH2 using plot scales

Return period (yrs)	**As-rural peak flow (m^3/s)**	As-rural direct runoff (ML)
1	0.032045	0.213721
2	0.035355	0.238226
5	0.048281	0.333946
10	0.05811	0.406791
25	0.071787	0.507766
30	0.074719	0.529315
50	0.082975	0.589863
75	0.089919	0.640659
100	0.095009	0.677786
200	0.107491	0.768345
500	0.12509	0.894603
1000	0.145506	1.039547

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500	0.12509	0.894603
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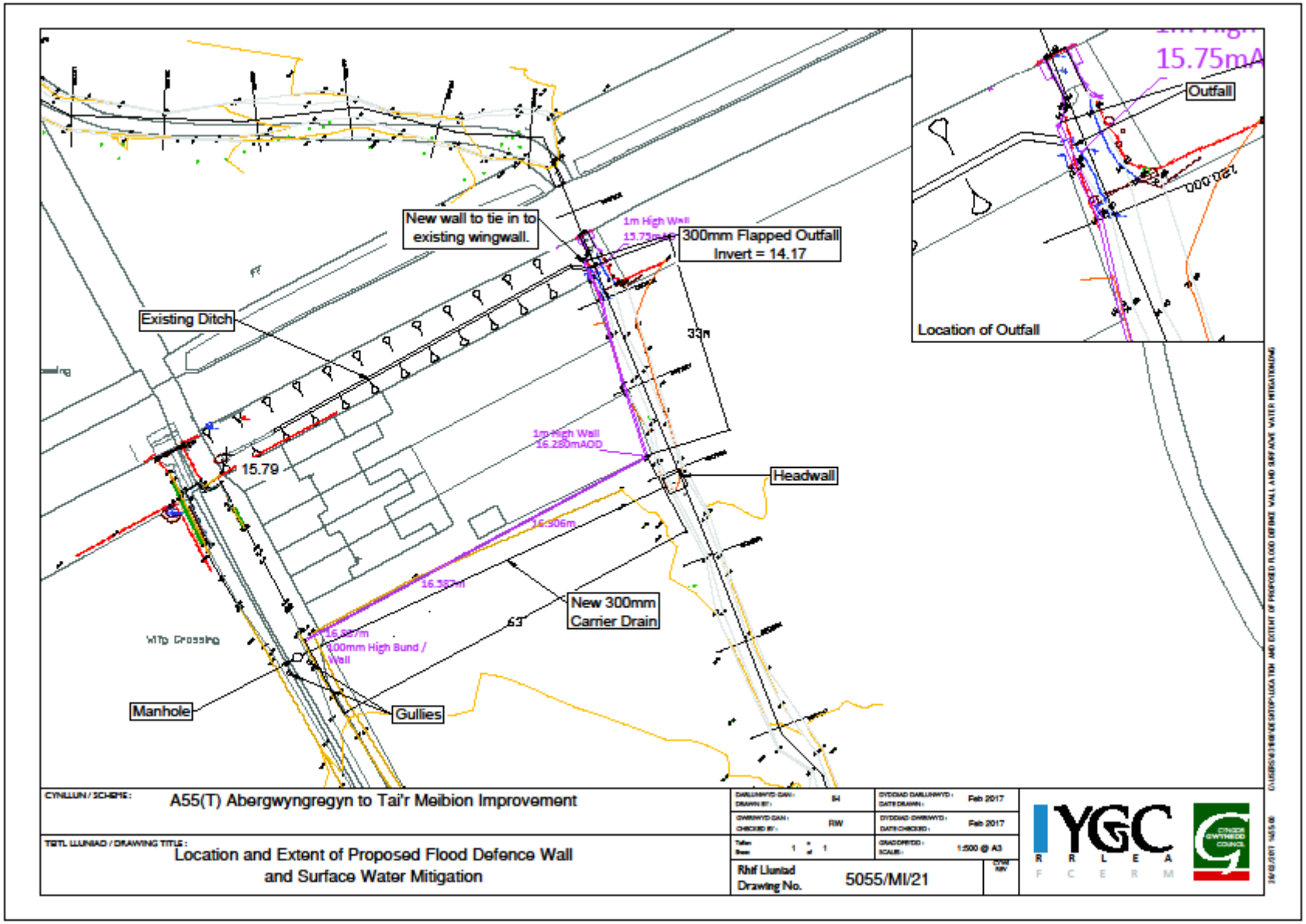
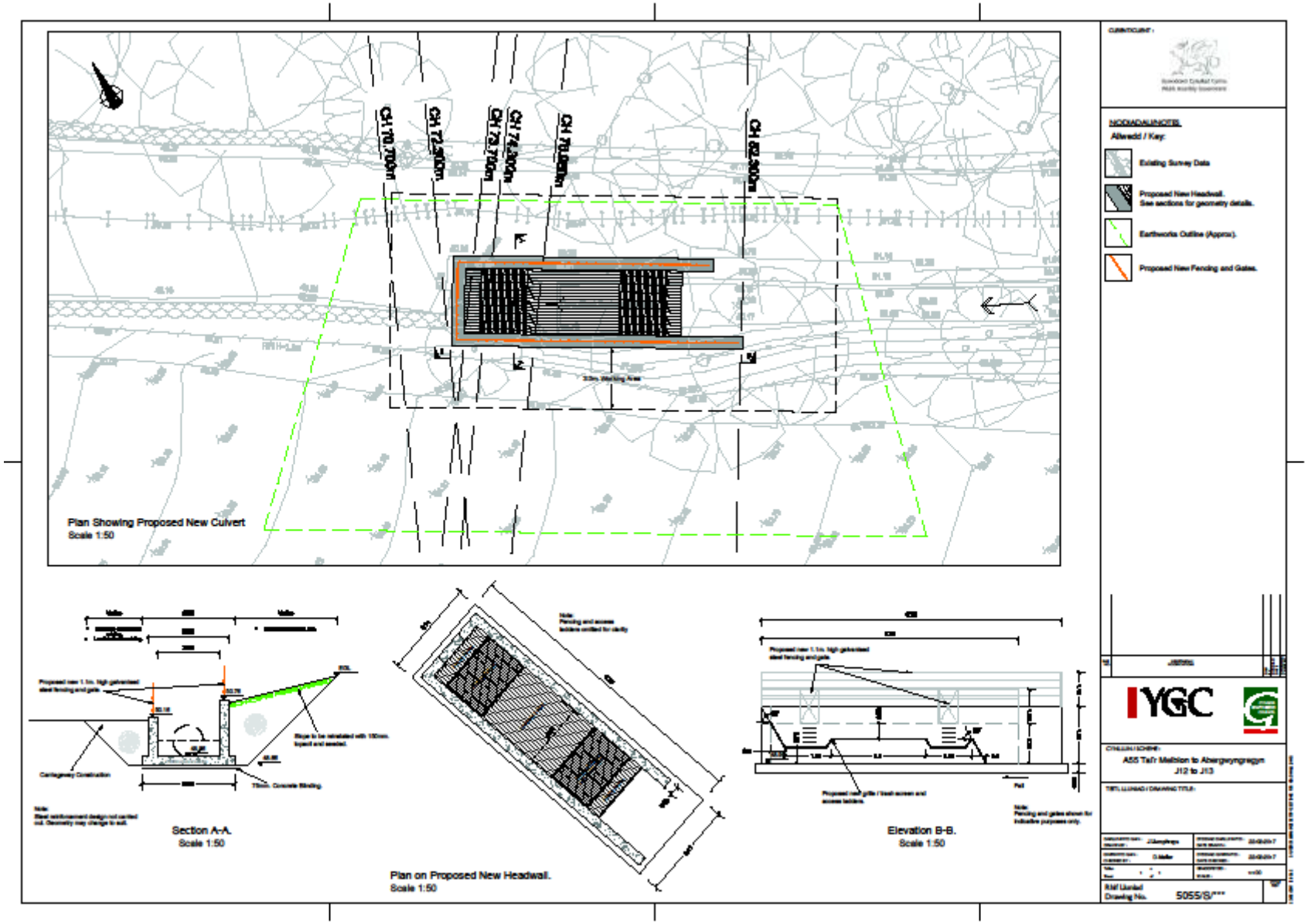
Appendix Z- Location and Extent of the proposed mitigation for Wig Crossing Cottages- Wall



Appendix Z1- Improvement works to Stream 1



A55(T) ABERGWYNGREGYN - TAI'R MEIBION IMPROVEMENT

EROSION PREVENTION AND SEDIMENT CONTROL PLAN

CPF 5055

Document Control Sheet

Document Author:	Petra Irvine
Project Manager:	David Meller

Revision History

Date	Version No.	Summary of Changes
21/04/16	0.01	
01/08/16	0.02	Fish Mitigation included
26/10/16	0.03	Updated to include description of lining of Stream 8

Approvals

Approved by	Signature	Date	Version
R. Williams		17/10/16	0.01
R. Williams		26/10/16	0.02

Distribution

Name	Title	Date	Version

ISO9001:2008
FS526386

ISO14001:2004
EMS 526388

OHSAS18001:2007
OHS 526389

EROSION PREVENTION AND SEDIMENT CONTROL PLAN

Introduction

Erosion is a natural process by which soil and rock material is loosened and transported. Erosion by the action of water, wind, and ice has produced some of the most spectacular landscapes. Natural erosion occurs primarily on a geologic timescale, but when human activities alter the landscape the process of erosion can be greatly accelerated. Construction site erosion causes serious and costly problems, both on-site and off-site. Waterborne soil erosion process begins by water falling as raindrops and flowing over bare soil surface.

When land is disturbed at a construction site, the erosion rate accelerates dramatically. Since ground cover on an undisturbed site protects the surface, the removal of that cover increases the site's susceptibility to erosion. Disturbed land may have an erosion rate 1,000 times greater than the pre-construction rate. Even though the process of construction requires that land be left bare for periods of time, proper planning and use of erosion prevention measures can reduce the impact of accelerated erosion caused by land development.

Identifying erosion problems at the planning stage and noting highly erodible areas helps in selecting cost effective, environmentally sensitive erosion control measures. This plan focuses primarily on the prevention of sedimentation associated with water and wind generated soil erosion.

Erosion control measures are required for construction areas where the ground surface will be disturbed by clearing, grading, fills, excavations and other construction activities. When developing an effective ESCP, there are several important concepts to consider:

- Timing - schedule work to minimize overall impacts
- Stage work - identify & process critical areas first
- Minimize disturbance - create buffers & reduce mass grading
- Pre-construction - during preliminary design & prior to on site grading activities
- Pictures/Video - documentation throughout life of project

Proposed Erosion prevention and Sediment Control Plan

The first aim of the erosion prevention and sediment control plan should be to minimise erosion by reducing disturbance and stabilising exposed materials. The plan will then consider control measures to minimise the release of mobilised sediment which result despite the erosion control measures. It is necessary to consider how the impacts of the

development may affect the relevant catchment or the river basin. The Water Framework Directive (WFD) requires the preparation of River Basin Management Plans (RBMPs) showing all significant impacts to the waters in a particular river basin. The interaction of new impacts from highway works with existing impacts may well produce cumulative impacts.

A cumulative impact is such where two or more streams in the same river basin are affected by the same project. This is likely to arise when a road runs parallel to a watercourse for over a kilometre. Assessment should consider the impacts to the receiving river as well as the streams themselves, even if the river is remote from site.

The RBMP produced by the Environment Agency (EA) will show where development in a river basin may have increased rates of run-off. Where highways are being improved and include existing culverts, an assessment should be made to the culvert's capacity, even if it will not be affected by the project.

Temporary Effects

Temporary effects from the construction of a project may be cumulative. For example, spoil from an excavation could be washed into a river as a result of a severe rainfall event. Depending on the nature of the watercourse, small discharges of spoil could accumulate on the river bed, leading to a risk of ecological damage to any fish and their spawning areas.

There can be a particular risk if the material has been imported to site, as its presence may cause a change to the chemical as well as physical quality of the water. Details of further assessment criteria can be found in chapter 5 Procedure for Assessing Impacts (5.49) in the DMRB, Volume 11, Section 3, Part 10, HD 45/09.

To reduce increased risk from erosion and sediment mobility within the Proposed Improvement, baffle weirs on culverted watercourses flowing to open streams will be incorporated.

Proposed Controls

Baffle weirs will be put in place as a form of energy dissipation on the downstream outlet of culverts 1, 2, 3, 5 (Wig), 6 and 8 which flows into an open stream/ river. The reduction in speed (energy) of the water will reduce the rate of erosion and will reduce the speed of transportation of sediments downstream. The baffle weirs were chosen as they were the only energy dissipation option which allowed fish and eels to move freely up and down the streams through the culverts.

Streams 1, 2, 3, 5 (Wig) 6 and 8 will be modified to accommodate the new baffle weirs.

Streams 1 and 8 currently have significant erosion problems which will be significantly improved post Proposed Improvement. The addition off baffle weirs will reduce the velocity at which the water currently flows through the streams and will therefore reduce the rate of erosion specifically within these two streams.

Stream 8 will be lined for 200m, downstream of the A55(T). The lining is proposed to reduce the erosion rates currently occurring within the stream channel and banks. The lining will comprise of a flexible geotextile material that will line the stream channel and replicate the current channel. The stream material will be placed on-top of the lining to further replicate the natural channel. The incorporation of the lining will significantly reduce erosion rates. Stream 8 will receive increased water volumes from new discharge points. Increased volumes of water has the potential to increase erosion, the lining will reduce any increased erosion rates as a direct result of increased water volumes.

Following the guidelines in the DMRB, Volume 11, Section 3, Part 10, HD 45/09, steps will be followed to ensure the risk of increased erosion does not occur and increased sediment mobilisation is not increased. Measures to prevent erosion are more effective than controlling sediment once mobilised. It is estimated that the construction phase of the project will not increase erosion or sediment within the streams. The use of baffle weirs will further slow the speed of the water which will reduce erosion rates for the long term.

The nature of the topography of the area results in high runoff rates (for geology and soil type see chapter 5.5, Environmental Statement). The area comprises mainly of unimproved agricultural land. Potential impacts from sediment mobilisation and erosion will not be increased during or as a result of this Proposed Improvement.

Streams with significant erosion problems (1 and 8) will be significantly improved post Proposed Improvement. The addition of energy dissipation measures will reduce the velocity at which the water currently flows through the streams.

The installation of in-river structures such as road culverts can pose limitations upon the ability of migratory fish to move freely towards upstream reaches of a watercourse under particular flow conditions, this will have a consequential impact upon the status of fish species within a watercourse. Common problems to fish movements which could be created by the proposed improvement are described below.

Perching is a term applied to a culvert outlet (the downstream end) which is set above the stream bed immediately downstream, so that there is a fall. This can occur when the culvert is installed too high, resulting in erosion of the downstream channel. While salmon and trout

are capable of leaping at falls to surmount them, conditions at culvert outlets are frequently not conducive to successful jumps. The stream below the fall may be shallow and the water turbulent, representing poor conditions for "take off" for a leap. Shallow, fast flowing water inside the culvert barrel presents difficult conditions for fish landing after a leap and the fish may be washed downstream out of the culvert.

Changes in the stream hydraulics either at the culvert inlet resulting from the constriction of the flow into the culvert barrel, as a results of increased gradient within the culvert or where a culvert ties into the existing bed levels, may cause problems to fish passing upstream; this poses particular problems for poorer swimmers such as eels. The problem becomes more severe in periods of high flow and in installations with smooth contours. If fish have to attempt passage through a culvert without the opportunity to rest immediately downstream, or have to continue strenuous swimming having just ascended a challenging culvert, they may become exhausted and be washed back downstream. A lack of rest areas and pools immediately upstream and downstream can thus render a difficult but theoretically passable culvert effectively impassable.

Measures to help avoid the problems described above will be considered during detailed culvert design, and will be informed by various technical design guidance published by the Environment Agency (EA) and the Scottish Environmental Protection Agency (SEPA). Such design measures may consist of the following:

A55(T) ABERGWYNGREGYN - TAI'R MEIBION IMPROVEMENT

WATER FRAMEWORK DIRECTIVE (2000/60/EC) INITIAL COMPLIANCE ASSESSMENT

CPF 5055

Document Control Sheet

Document Author:	Petra Irvine
Project Manager:	David Meller

Revision History

Date	Version No.	Summary of Changes
04/11/15	0.01	
09/12/15	0.02	Updated tables for 2015 water samples
09/03/16	0.03	Updated grid references
26/10/16	0.04	Final Version following WG comment

Approvals

Approved by	Signature	Date	Version
R. Williams		17/10/16	0.03
R.Williams		**4/11/16**	**0.04**

Distribution

Name	Title	Date	Version

ISO9001:2008
FS526386

ISO14001:2004
EMS 526388

OHSAS18001:2007
OHS 526389

Contents

1.0 The Project

1.1 Context

A55 (T) Abergwyngregyn to Tai'r Meibion Improvement

The Welsh Government have commissioned YGC to carry out a re-design of a previous proposal to improve a 2.2 km section of the A55(T) from Abergwyngregyn (Grid Reference: 265195, 372692) to Tai'r Meibion (Grid Reference: 26602, 371197) as this section of the A55(T) is no longer compliant with current standards. Through improving the road safety, additional drainage of the section will be included, combined with updating and improving current drainage. With improved drainage from the A55(T), the surrounding land may be recipient of increases in water; it is therefore essential that a flood consequence assessment (FCA) is carried out. Combined with this, within the Proposed Improvement area, there are 8 watercourses and two field drainage features (all of which are culverted/ piped under the A55(T)). Due to potential increases in water being drained from the A55(T) into the watercourses, there is a need to assess the current water quality in line with Water Framework Directive (2000/60/EC) (WFD) guidelines to ensure that during and post construction no negative impacts are caused to the water environments.

1.2 Background

This section of the A55(T) is now over 38 years old and the vertical alignment, although originally designed to standards current at the time, does not comply with the present-day standards to which the adjacent sections have been built. The current forward visibility distances are significantly below existing requirements and the Proposed Improvement would aim to address this deficiency. The latest standards also require 1m wide hard strips on each side of both carriageways.

The central reservation gaps, private entrances, field accesses and junction to the Class 3 County Road are often used by slow-moving vehicles, which is a detriment to the free and safe flow of through traffic on the A55(T).

After many years of routine and structural maintenance involving surface treatment, the road pavement has reached the end of its useful life and it is therefore necessary, as a minimum, to overlay the existing pavement with new bituminous material.

Following heavy storms in recent years flooding has occurred, particularly at the west end of the Proposed Improvement, which has resulted in the closure of one or both carriageways. Improvements to the drainage system are therefore required to alleviate this problem for the future. Culverts also act as discharge points for the surface water drainage from the main carriageway and improvements are required to drain this water effectively. Increased attenuation will be incorporated into the updated drainage design.

1.3 The Scheme

The scheme will run from Abergwyngregyn along the A55 (T) for approximately 2.2km to Tai'r Meibion (see Appendix 1). The scheme is proposed to improve the safety and drainage of this section of the A55(T). Through realignment, widening and increased drainage ability the section will conform to modern standards. As there are 8 watercourses within the footprint of the Proposed Improvement it is essential that any works do not pollute or damage the water environment of the watercourses. The Proposed Improvements must also follow the guidelines set out by the WFD legislation[1] and not cause negative effects to the water environment, water quality, ecosystems or biodiversity.

The proposed drainage design extends over a length of approximately 3.2km from the Tal y Bont interchange (Junction 12) to the stream adjacent to Pentre Aber Farm (in order to cater for the new county road and NMU route to the north of the A55(T) in addition to the A55(T) improvement itself). Eight minor watercourses are crossed, each being currently culverted under the A55(T). The culverts are located near Llain Ffwlbart (Grid Reference: 262195, 371160), near the junction with Roman (Henffordd) Road (Grid Reference: 262502 371417), near Tan-yr-allt cottages(Grid Reference: 262799, 371613), at Tai'r Meibion Farm (Grid Reference: 263080, 371755), at Wig Farm (Grid Reference: 263449, 371917), at the former site of Wig Bach (Grid Reference: 264012, 372157), at Bryn Meddyg (Grid Reference: 264512, 372369) and at Pentre Aber Farm (Grid Reference: 264976, 372569).

[1] Water Framework Directive (WFD)- The WFD requires us to aim to meet good status in all water bodies. The Water Framework Directive (Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy) is a European Union directive which commits European Union member states to achieve good qualitative and quantitative status of all water bodies (including marine waters up to one nautical mile from shore) by 2015 (2027 in some areas).

For surface waters, good status is made up of 'good ecological status (GES)' (or good ecological potential (GEP) where artificial or heavily modified[1]) and 'good chemical status'.

Ecological status and potential are made up of a number of biological, hydromorphological and physico-chemical quality elements. Chemical status is recorded as either good or failing.

For a groundwater water body to be in overall 'good' status, both quantitative and chemical status must be 'good'.

Where water bodies are currently at less than good status we have planned a series of improvement measures.

The WFD also requires prevention of deterioration in water body status including deterioration of any of the individual quality elements. The 'no deterioration position statement' gives further information on this requirement.

Further investigation will be required on site to determine the condition of each culvert and suitability for connection prior to detailed design.

The Proposed Improvement involves the on-line widening of this section of the A55(T) dual carriageway trunk road to current standards with hard strips. A new central concrete vehicle containment barrier will be constructed and two existing cattle creeps will be extended. A new 1.6km county road will join the Tal y Bont interchange (Junction 12) with the Wig Crossing Cottages junction.

During construction it will be necessary to implement a wider culvert on stream 5 and 8 (see appendix 1). The FCA will be carried out for this upgrading and upsizing and suitable measures will be put in place to ensure flooding is not increased downstream. Measures will also be implemented to ensure that there are no negative effects to the water quality through the construction or post construction of the culverts. Ensuring that increased sedimentation does not occur will be of significant importance.

1.4 The Project and reasons for the Project

The project is necessary as the section of the A55(T) no longer complies with current safety standards. The section of the A55(T) is also prone to flooding and therefore the proposed works are designed to increase safety and alleviate flooding to the area. The Proposed Improvements will also improve access and safety to the residential properties along the A55(T), through the construction of a new county road.

1.5 Past Flooding

The A55(T) has had a number of flooding incidents between J13 and J12 (the section running between Abergwyngregyn and Tai'r Meibion).
In 2012 the A55(T) flooded to such an extent that complete road closure occurred for 12 hours.

During another intense rainfall event in 2014 partial closure occurred with single lane use in both directions.

Following a period of heavy and prolonged rainfall in December 2015 the A55(T) suffered flooding again. flooding incidents affecting between J13 Abergwyngregyn and J12 Talybont (i.e. the 'old' section') both on the evening of Thursday 3rd and Saturday 12th On both

occasions, it was deemed that, due to the adjacent agricultural land being saturated, and at a higher level, surface water was flowing into the carriageway. On both occasions overflowing surface water was restricted to lane 1 of the westbound carriageway and a lane closure was implemented overnight both times.

Further flooding affecting the A55 between J13, Abergwyngregyn and Tai'r Meibion occurred over the recent Christmas period and that, effectively, the event timeline was as follows:

Friday

25/12/15 - 18:23 - W/B Lane 1 closure due to surface water flowing onto carriageway from adjoining agricultural land at numerous locations;

Saturday

26/12/15 – 07:05 – W/B fully closed due to amount / volume of water across carriageway (closed at J15 as per TM plan;)
26/12/15 – 07:33 – W/B remains closed & E/B closed due to volume of water (E/B closed at J11 as per TM plan);
26/12/15 – 21:34 - W/B remains closed & E/B now open
26/12/15 – 23:56 – W/B reduced to Lane 1 closure (J13 – J12)

Saturday 16/12/15 – Monday 04/01/16

W/B Lane 1 closure (J13 – J12) remains due to ongoing water seepage onto carriageway

Monday

04/01/16 – 11:00 – W/B Lane 1 removed

As previously, due to the adjacent agricultural land being totally saturated as a result of the recent rainfall and, it being at a higher level, surface water was flowing into the carriageway.

All existing trunk road surface water drainage infrastructure appeared to be operational although a large volume of stones/ debris was removed by machine from the stream at the inlet to the culvert at Tai'r Meibion (the last culvert travelling westbound prior to Tai'r Meibion). This stream had also been cleaned of similar debris following the flooding event of 12/12/15.

However, surface water was flowing onto the A55 at a number of locations both from the fields but also from access roads/ entrances along this section, which, due to the nature and restrictions of the existing alignment and infrastructure are very difficult to control.

It was noted that these 'streams' were being created both due to the extremely saturated ground conditions but also by watercourses being 'redirected' due to blocked culverts at higher ground and therefore not following the natural path.

1.6 Project Objectives

The overall objective of the scheme is to improve safety standards of the A55(T), rather than increase the capacity of the existing carriageway for traffic flow. The key aims include:

- Improving the forward visibility and safety standards along the existing section by adding 1m wide hard-strips and improving the vertical alignment and surfacing of the carriageway.
- Improving the safety for moving vehicles on the carriageway by closing central reservation gaps, private entrances, field accesses and the junction to the class 3 county road and providing suitable alternative means of access for the properties affected.
- Enhancing the existing cattle underpasses to meet current structural standards and remain functional for future use.
- Addressing the problem of flooding by improving the existing drainage system.
- Reducing the likelihood of accidents occurring by improving the safety standards to meet current requirements.

2.0 Report Introduction

This report will outline the watercourses within the study area, the water samples taken and their current quality status. The report also provides a summary of the proposed mitigation measures to ensure that water quality is not affected during construction following the Water Framework Directive (2000/60/EC) guidelines for developments in and around water courses. This report is summarised in Chapter 5.10 (Road Drainage and the Water Environment) of the Environmental Statement. This WFD Compliance Assessment supports Chapter 5.10 with additional information regarding water quality and pollution mitigation measures.

The main source of pollution to the watercourses within the Proposed Improvement area is from vehicle emissions. Vehicle emissions include volatile solids and PAHs (Polycyclic aromatic hydrocarbons) derived from unburned fuel, exhaust gases and vapours, lead compounds (from petrol additives), and hydrocarbon losses from fuels, lubrication and hydraulic systems.

Pollutants are generated by the everyday passage of traffic. Tyre wear releases zinc and hydrocarbons. Vehicle corrosion releases pollutants such as iron, chromium, lead and zinc. Other pollutants include metal particles, especially copper and nickel, released by wear of clutch and brake linings. Most metals are predominantly associated with the particulate phase.

Wear of the paved surface will release various substances: bitumen and aromatic hydrocarbons, tar and emulsifiers, carbonates, metals and fine sediments, depending on the road construction technique and materials used.

Runoff quality will depend upon a number of factors, including:

- Geographical location
- Road and traffic characteristics
- Buildings and roofing types
- Weather, particularly rainfall.

2.1 Legislative background

Introduction to the Water Framework Directive (2000/60/EC)

The Water Framework Directive (2000/60/EC) is a European Directive which sets out a strategic planning process for the purposes of managing, protecting and improving the water environment. The WFD introduces new environmental requirements which aim to meet good status in all water bodies. For surface waters, good status is made up of 'good ecological status (GES)' (or good ecological potential (GEP) where artificial or heavily modified) and 'good chemical status'. Ecological status and potential are made up of a number of biological, hydromorphological and physio-chemical quality elements. Chemical status is recorded as either good or failing. For groundwater to be in overall 'good' status, both quantitative and chemical status must be 'good'. The WFD also requires prevention of deterioration in water body status including deterioration of any of the individual quality elements.

The main objectives of the WFD are to:

- Prevent deterioration in the status of aquatic ecosystems, protect them and improve the ecological condition of waters;

- Aim to achieve at least 'Good Status' for all waters by 2015 (2021 or 2027 where fully justified within an extended deadline under Article 4.4);
- Promote sustainable use of water;
- Conserve habitats and species that depend directly on water;
- Progressively reduce or phase out the release of individual pollutants or groups of pollutants that present a significant threat to the aquatic environment;
- Progressively reduce the pollution of groundwater and prevent or limit the entry of pollutants; and
- Help reduce the effects of floods and droughts.

New activities and schemes that affect the water environment may adversely impact biological, hydromorphological, physico-chemical and/or chemical quality elements (WFD quality elements), leading to deterioration in water body status. They may also render proposed improvement measures ineffective, leading to the water body failing to meet its WFD objectives for GES/GEP. Under the WFD, activities must not cause deterioration in water body status or prevent a water body from meeting GES/GEP by invalidating improvement measures.

2.2 Purpose of the report and WFD compliance assessment approach

The WFD Initial Compliance Assessment is carried out to firstly establish the water quality of the watercourses that exist within the area of the Proposed Improvement. From these data it will be possible to monitor the water quality pre, during and post construction. Establishing the initial water quality can allow for measures to be put in place to either improve the water quality or ensure no degradation of the current water quality occurs. This document sets out the initial WFD screening assessment and comprises a summary overview, quality element assessment, results and recommendations. The assessment will take account of hydromorphology, aquatic ecology, water quality and groundwater.

The WFD Compliance Assessment is complimentary to Chapter 5.10 of the Environmental Statement and provides a detailed report on current water quality, current legislation and future mitigation and management during and post construction.

2.3 Environmental objectives

The following environmental objectives (based on Articles 4.1, 4.8 and 4.9 of the WFD) were used to make recommendations on WFD compliance in relation to the Proposed Improvement. The Objectives have been devised specifically for the Proposed Improvement:

- Objective 1: The Scheme will not cause deterioration in any element of water body classification.
- Objective 2: The Scheme will not prevent the WFD status objectives from being reached within the water body or other downstream water bodies.
- Objective 3: The Scheme will not negatively impact critical or sensitive habitats within the scheme area.
- Objective 4: The Scheme will ensure that an increased level of hydrocarbons into watercourse does not occur.
- Objective 5: The Scheme will not impact upon any European designated sites within the area of the Proposed Improvement[2].

2.4 Consultation carried out to date

The table below summaries the consultations that have been carried out to date. The consultees and the organisations are listed in relation to the consultation that was carried out. All issues raised from consultations have been addressed

Table 1.0 Summary of consultation and consultees to date

Name and organisation	Subjects Discussed	Key issues raised	Date
Gwynedd Council	Flood and Water Management Act, Land Drainage Act and Council culverting policy in relation to ordinary watercourses	Rights and responsibilities, consents required and what works can be undertaken	2016

[2] Menai Strait and Conwy Bay SAC (Special Area of Conservation) and Traeth Lafan SPA (Special Protection Area located 625m north of the scheme boundary and there are fluvial pathways linking the scheme to the sites. It is not considered that features of the sites, with particular reference to the SAC habitat features 'Sandbanks which are slightly covered by sea water all the time'; 'Mudflats and sandflats not covered by sea water at low tide' and 'Large shallow inlets and bays' would be negatively affected by the scheme's construction, as long as suitable mitigation measures are in place to control possible water-based pollution.

Name and organisation	Subjects Discussed	Key issues raised	Date
NMWTRA	Flooding of the highway Access roads within the Proposed Improvement area	Maintenance of the culvert grids, response to flooding and length of flooding on the highway Identifying all roads that may be affected by the Proposed Improvement	2016
Emyr Gareth (NRW) Iwan Huws (NRW)	Flood Risk	Incorporation of flood mitigation for Wig Crossing Cottages and inclusion of mitigation in hydraulic model. Railway culvert downstream of Wig Cottages to be included in the hydraulic model.	2015 2016
Phil Oliver (NRW)	Biodiversity	NRW to provide results of stream surveys regarding fish.	2016
Walter Hanks (NRW)	Fish Mitigation	Timeframe of when works may be carried out within river and mitigation measures to reduce siltation and fish rescues.	2015/2016
Mark Medway (NRW)	Pollution controls	Incorporation of grassed swales into design	2016
Environment Liaison Group Meeting- Jenny Emmett – GAPS Emily Meilleur – GC Jill Jackson – NMWTRA Peter Evans – NRW Mark Medway – NRW Phil Oliver – NRW Ruth Prichard – NRW Luci Collinwood – WG Sasanka Fernando – WG Chris Jones – YGC David Meller – YGC Christian Middle – YGC Nancy Wilkinson -YGC Robert Williams – YGC	Environmental Protection	Pollution prevention measures, mammal passages, geomorphology and hydromorphology.	2016

3.0 WFD screening assessment

3.1 WFD Classification

The WFD classification for a defined water body is produced by assessment of a wide variety of different 'elements' which includes:

- 'biological elements' such as fish, invertebrates, phytobenthos (which includes plants, macro-algae and phytoplankton);
- 'supporting elements' that include chemical measurements such as ammonia, dissolved oxygen, pH, phosphate, copper, zinc and temperature; and
- 'supporting conditions' (sometimes referred to as hydromorphology), that assess the physical attributes of the water body such as 'quantity and dynamics of flow' and 'morphology'.

The assessment given for each element is also accompanied by a measure of certainty in the result. The status classification is published in the River Basin Management Plan (RBMP)[3] and provides a baseline condition against which compliance and future improvements can be measured.

WFD Compliance

There are three key WFD objectives against which the impacts of proposed works on a water body need to be assessed to determine compliance with the overarching objectives of the WFD:

- Objective 1: The Scheme will not cause deterioration in any element of water body classification.
- Objective 2: The Scheme will not prevent the WFD status objectives from being reached within the water body or other downstream water bodies.
- Objective 3: The Scheme will contribute, if feasible, to the delivery of the relevant WFD objectives. In this case it will be what contribution the Scheme can make towards the water body reaching its objective Good Ecological Potential (GEP) through planned RBMP mitigation measures.

The first two WFD objectives listed above must be met to avoid infraction of the overarching aims of the WFD. The delivery of the third objective is central to the overall WFD purpose, where practical and feasible the proposed works will work towards improving water quality status in line with the WFD. In the very minimum, it will be ensured that no adverse changes to water quality will occur during the construction and/ or operational phases of the works.

[3]Western Wales RBMP- By 2015, 13 per cent of surface waters (rivers, lakes, estuaries and coastal waters) in this river basin district are going to improve for at least one biological, chemical or physical element, measured as part of an assessment of good status according to the WFD. Currently only 29 per cent of surface waters are currently classified as good or better ecological status/potential. 51 per cent of assessed surface water bodies are at good biological status.

If it is considered that the scheme is likely to cause deterioration in water body status or prevent a water body from meeting its ecological objectives then an assessment would be made against the conditions listed in Article 4.7 of the WFD. Article 4.7 can be invoked if; 'new modifications' are of overriding public interest and/or the environmental and social benefits of achieving the WFD objectives are outweighed by the benefits of the new modifications to human health, safety and sustainable development; there are no significantly better environmental options that are technically feasible or not disproportionately costly; and all practicable steps for mitigation have been taken.

3.2 Summary Overview

The scheme will be building upon and widening existing infrastructure. The road will be widened to include 1m hard-strips on either side of the road. This will increase the surface area of impermeable road surface; however drainage will be increased through updated and upsized pipes combined with an attenuation pond. The attenuation pond is key in reducing the rate at which the water drains directly into the watercourses. The pond will also act as pollution control and allow sediment to settle to reduce increased sedimentation and pollution entering the watercourses.

3.3 Screening assessment of impacts on water body quality elements

For most of the length of the Proposed Improvement, surface water runoff from the fields on the southern side would be collected via the new bund and channel system.

Lengthening culverts has the potential to impact upon the hydromorphology of the streams. Hydromorphology is a key contributor to GES and GEP of streams following WFD guidelines. Streams 5 and 8 will require upsizing of culverts to allow for a 1 in 100 year +CC storm event (see Section 3.5 for further details). The culverts will be kept as short as possible, where reasonably practicable; the gradient of steep channels will be eased out to reduce flow velocities, stepped slipways will be removed which will further promote fish migration and mammal movement. The design mitigation including consideration of design features aligned with the objectives of the WFD (for example use of soft engineering solutions, aquatic marginal planting and the inclusion of natural forms) will ensure that the channels and structures are sufficiently sized to avoid a permanent impact on flow.

The remaining streams have adequate culverts and the economic viability of upsizing these is not considered to be feasible. The culverts within these streams are of adequate size and condition.

Initial water samples were tested in 2006/2007 and the results showed that the current overall quality of the watercourses was good or high. The Afon Aber catchment was classed as high. At the time of sampling the water was not tested against the WFD guidelines, as the WFD was not published at this time.

Resampling of the watercourses has been carried out in 2015 to ensure the current water quality information is up to date and in-line with WFD guidelines. The sampling was carried out on the 05/11/15 and the 11/11/15 (one dry day and one wet day). The downstream water samples will indicate the current water quality also giving an indication of the amount of hydrocarbons currently entering each water course from the A55(T). Streams 1-5 had an overall WFD classification of Moderate and Streams 6-8 had an overall WFD classification of Good.

3.4 Streams

The following streams are present within the footprint of the Proposed Improvement. Please refer to Appendix 1 for a plan of the stream locations.

Stream 1

Stream 1 is culverted from a point adjacent to Ty'n Hendre and runs north into a series of chambers. The system picks up drainage from filter drain networks on both sides of the A55(T) carriageway, passing under the Tal y Bont Interchange (Grid Reference: 262195 371160), and then outfalls some 80m north-west of the A55(T) and flows north towards the Menai Strait. Within the study area it is classed as an ordinary watercourse, falling under the responsibility of the riparian landowner. It is classed as a 'Main River' by NRW (Afon Ty'n Hendre) from the point at which it passes under the railway line (approximately 280m north of the proposed county road).

NRW estimated data show that Afon Ty'n Hendre has an Average Daily Flow of 15.7 l/s and a Q95 (flow that is exceeded 95% of the time) low flow discharge of 1.6 l/s.

Culvert will be extended at stream 1 to allow for the crossing of the new county road. Baffle weirs, battering of banks and brush matting to the downstream channel banks would be incorporated.

Stream 2

Stream 2 passes under the A55(T) through a 1050mm diameter pipe (Grid Reference: 262502 371417) and receives a portion of the surface water for the adjacent junction through two gullies located on the junction. The stream outfalls directly north of the A55(T) and the pipe would be extended to pass under the proposed county road.

Stream 2 would be used to discharge runoff from the new county road. The existing 1050mm diameter pipe culvert beneath the A55(T) would be extended to carry the stream beneath the new county road. A drain would be piped directly into the existing culvert to discharge runoff from the kerb and gully system.

Stream 3

A 1050mm diameter pipe carries stream 3 under the A55(T) (Grid reference: 262799 371613) to two chambers before out-falling at a headwall on the north side of the A55(T). The pipe would be extended to pass under the proposed county road.

Stream 3 would be used to discharge runoff from the new county road. The existing 1050mm diameter concrete culvert would be extended to the north to pass under the new county road. A new headwall would be constructed on the eastern side of the watercourse to discharge piped runoff from the kerb and gully system on the new county road.

Stream 4

Stream 4 is culverted from a point near the Roman Road to the south of the A55(T) to a chamber at the south side of the westbound carriageway. From here a 600mm diameter pipe carries the stream under the A55(T) (Grid Reference: 263080, 371755) to a chamber at the north side of the eastbound carriageway and subsequently into a stone culvert, carrying the stream north towards the railway.

It is classed as a 'Main River' by NRW (Afon Tai'r Meibion) from the point at which it passes under the railway line (approximately 310m north of the new county road).

NRW estimated data show that Afon Tai'r Meibion has an Average Daily Flow of 23.8 l/s and a Q95 low flow discharge of 2.4 l/s.

Stream 4 would be used to discharge runoff from the kerb and gully system, which would discharge via a proposed pipe into an existing chamber on the line of the existing culvert.

Stream 4 would also be used, as at present, to carry runoff from the Proposed Improvement over a length of 300m by a filter drain in the northern verge, and by a system of surface water channels and carrier drains in the southern verge. The Proposed Improvement would drain into Stream 4, via both the proposed system of surface water channels and filter drains and by direct connection of the existing land drainage immediately east of Tai'r Meibion Farm into the existing culvert beneath the Proposed Improvement. The existing culvert would need to be extended to the north to accommodate the new county road and to the south to accommodate the increased overall width of the highway.

Stream 5

Stream 5 is culverted under the A55(T) via a 1050mm diameter pipe, which outfalls at the north side of the eastbound carriageway. Stream 5 flows northwards through Coed Wern-Porchell and is culverted under the A55(T) (Grid Reference: 263449 371917), upon which it becomes classed as a 'Main River' by NRW (Afon Wig). It is shaded by trees on both sides of the A55(T), although to a greater extent on the northern side.

NRW estimated data show that it has an Average Daily Flow of 66.6 l/s and a Q95 low flow discharge of 6.7 l/s; indicating that the stream generally carries more water than Streams 1, 4, 6 and 7 (and probably 2, 3 and 8), particularly during periods of low flow.

Stream 5 (Afon Wig) would be used, as at present, to discharge runoff from the Proposed Improvement between chainages 400 and 660 (see Figures 2.2 to 2.4, Volume 1a), via a filter drain in the northern verge, and by a system of surface water channels and filter drains in the southern verge. The existing culvert would be replaced by a much larger structure to accommodate 100 year plus climate change flows. In addition, runoff from the adjacent fields on the southern side of the Proposed Improvement would drain into Stream 5 via a bund and channel system.

Stream 6

Stream 6 is culverted under the A55(T) via a 800mm diameter pipe, there is an overflow pipe located in the chamber in the central reserve, and eventually outfalls back into stream 6 some 28m north of the outlet headwall.

Stream 6 runs steeply through an open field on the southern side of the existing carriageway before entering a culvert, which takes it under the A55(T) (Grid Reference: 264012, 372157). The stream re-emerges in an area of woodland and then flows through an area of open, improved pasture before reaching the coast.

Stream 6 varies widely in its characteristics and is heavily influenced by local topography and landscape features. It is not classified as a 'Main River' but NRW estimated data show that it has an Average Daily Flow of 16.95 l/s and a Q95 low flow discharge of 1.7 l/s.

Stream 6 would be used, as at present, to discharge runoff from the Proposed Improvement between chainages 660 and 1400 (see Figures 2.2 to 2.4, Volume 1a), via the proposed filter drain in the northern verge, and by a system of surface water channels and filter drains in the southern verge. To the east and west of Stream 6, the filter drains and filter pipe system would combine to outfall into a detention pond at the site of Wig Bach (Grid Reference: 263975, 372173) to prevent flooding from the large catchment area of rural runoff from the south of the Proposed Improvement. The existing culvert would need extending to both the north and south. In addition, runoff from the adjacent fields on the southern side of the Proposed Improvement would drain into Stream 6 via a bund and channel system.

Stream 7

Stream 7 is carried under the A55(T) via a 900mm diameter pipe to a chamber in the central reserve (Grid Reference: 264512, 372369) and then continues to another chamber in the verge of the eastbound carriageway before emerging approximately 280m downstream, in open grazed pasture where it passes under the railway line to run through more pastureland before entering the sea.

Stream 7 varies widely in its characteristics and is heavily influenced by local topography and landscape features. NRW did not hold any data on low flows though stream 7. On visual inspection the stream is similar in flow to Stream 6. As an estimate and for the purpose of this report the Q95 value of stream 6 (1.7 l/s) will therefore be used for Stream 7 (on visual inspection the stream is similar in flow to Stream 6).

Stream 7 would be used, as at present, to discharge runoff from the Proposed Improvement between chainages 1400 and 1800 (see Figures 2.2 to 2.4, Volume 1a), via the proposed filter drains in the northern verge, and by a system of surface water channels and filter drains in the southern verge. The filter drain to the west of Stream 7 would connect directly into the existing culvert. The filter drain to the east of Stream 7 would connect into an existing chamber. In addition, runoff from the adjacent fields on the southern side of the Proposed Improvement would drain into Stream 7 via a bund and channel system.

Runoff from the carrier system along the proposed access to Bryn Meddyg would also discharge into Stream 7 via direct connections into the extended culvert on the southern side of the Proposed Improvement. Additionally, the stream would collect runoff from the cut-off drains

along the southern side of the proposed access via a new connection into the extended culvert, south of the proposed access.

Stream 8

Stream 8 passes under the A55(T) (Grid Reference: 264976, 372569). NRW held no additional information on this stream. Stream 8 was similar in flow on visual inspection to Stream 6. As an estimate and for the purpose of this report the Q95 value of stream 6 (1.7 l/s) will therefore be used for Stream 8*. Proposal to extend energy dissipation to access road will be discussed with land owners and Natural Resources Wales at detail design stage.
*NRW held no information regarding the Q95 flow of streams 2, 3, 7 and 8. For the purpose of the Highways Agency Water Risk Assessment Tool (HAWRAT) the assumed flow of 1.70l/s has been allocated to streams 7 and 8. As it is not required to assess streams 2 and 3 using this tool the Q95 will not be assumed. However upon visual inspection of the streams the flow seen in streams 2 and 3 was similar to that seen in stream 4.

Stream 8 would be used, as at present, to discharge runoff from the Proposed Improvement between approximate chainage 1750 and the eastern end of the Proposed Improvement at chainage 2050 (see Figures 2.2 to 2.4, Volume 1a), via the proposed filter drain in the northern verge, and by a system of surface water channels and filter drains in the southern verge. The existing culvert would be upsized from a 300mm to a 1200mm diameter pipe and extended north beneath the NMU route. Stream 8 would also collect runoff from the fields on the southern side of the Proposed Improvement, via the proposed system of surface water channels and carrier drains.

Stream 8 will be lined for 200m, downstream of the A55(T). The lining is proposed to reduce the erosion rates currently occurring within the stream channel and banks. The lining will comprise of a flexible geotextile material that will line the stream channel and replicate the current channel. The stream material will be placed on-top of the lining to further replicate the natural channel. The incorporation of the lining will significantly reduce erosion rates. Stream 8 will receive increased water volumes from new discharge points. Increased volumes of water has the potential to increase erosion, the lining will reduce any increased erosion rates as a direct result of increased water volumes.

There would be a new installation of a 450mm diameter pipe across the field between the A55(T) and Roman Road just west of The Old School, tying into Stream 8; land drains would also feed into this pipe.

3.5 Upsizing Culverts

Any culvert or pipe that requires upsizing to a greater capacity needs to be assessed for its potential to cause increased flood risk. For this assessment only streams with properties downstream need to be assessed for their flood risk potential. Where streams drain fields and there are no properties within the area of the stream, no further assessment of flood risk needs to be done.

Stream 5 (Afon Wig, Grid Ref: 263449 371917) will require upsizing to a greater capacity as to be able to safely carry surface water from the A55(T). The upsizing will require a culvert that has a capacity to carry water during a 1 in 100 year +CC event. Downstream of stream 5 are the Wig Cottages (Grid Reference: 263295 372259), the upsizing of the culvert upstream must not increase flood risk to these properties. Using flood modelling software and GIS software it has been estimated that the upsizing of the culvert will not increase flood risk to the Wig Cottages properties downstream of the upsized culvert on Steam 5.

Stream 8 (Grid Ref: 264976 372569) will also require upsizing of the culvert to a greater capacity to be able to carry surface water from the carriageway for up to a 1 in 100 year + 30% climate change estimations event. Downstream of stream 8 there are no properties or infrastructure at risk of increased flood risk, therefore further assessment of the flood risks associated with the upsizing of stream 8 is not required.

Hydraulic modelling was carried out to illustrate the potential flood risks associated with upsizing the culvert at stream 5 (Afon Wig). Full details of the results can be found in the FCA, Volume 2, Technical Appendix D.

3.6 Previous sampling and Current status

From previous water samples carried out in 2006/2007 the water quality has been found to be of moderate or good status. The full results for the 2006/ 2007 sample results can be found in Appendix 3 with the 2015 sample results in Appendix 4.

Table 1.2 Overall WFD status for the catchments of each stream (based on 2006/2007 data)

Stream	Catchment	WFD Ecological Classification	WFD Chemical Classification
1	Ty'n Hendre	Moderate	Good
2	Ty'n Hendre	Moderate	Good

3	Ty'n Hendre	Moderate	Good
4	Un-named	Moderate	Good
5	Wig	Moderate	Good
6	Un-named	Good	Good
7	Un-named	Good	Good
8	Un-named	Good	Good

Table 1.3 WFD classification of the individual streams (based on 2006/2007 data)

Feature	Attribute	WFD Quality	Importance
Stream 1	Water Quality	Good	Very High
Stream 2	Water Quality	Good	Very High
Stream 3	Water Quality	Good	Very High
Stream 4	Water Quality	Good	Very High
Stream 5	Water Quality	Good	Very High
Stream 6	Water Quality	High	Very High
Stream 7	Water Quality	High	Very High
Stream 8	Water Quality	High	Very High
Groundwater	Vulnerability	Sections of the A55(T) Improvement and the new Class 3 road are underlain by a minor aquifer.	Medium

The streams are used as drainage points for the surrounding land and catchment. There are no abstraction licences, reservoirs or dams on any of the streams.

3.7 Screening assessment results and recommendations

Following consultation with Natural Resources Wales as there has been no change to land use and traffic volumes since 2006/ 2007. It was considered that all the previous analytes would not require re-testing. The following parameters were considered necessary for re-testing for the water sampling and monitoring in 2015:

- pH,
- conductivity,
- chloride,
- solids,
- turbidity,
- zinc,
- oil (if visible take sample, otherwise state not visible).
- Hydrocarbons

The parameters of particular concern are the level and type of hydrocarbons present within the watercourses. High levels of hydrocarbons within the watercourses would indicate high pollution levels from the road resulting in poor pollution control on the drainage outlets.

The current water quality based on these properties will determine the overall water quality for the streams within the Proposed Improvement area. Since the 2006/ 2007 samples, the addition of oil/ hydrocarbons within the sampling must be carried out. This will be essential for the Proposed Improvement as the amount of hydrocarbons within the water will indicate the level of pollution directly from traffic along the A55(T). Water samples were collected from each of the streams and analysed by ALS Environmental.

Sample set 1:
On the day of sampling (05/11/15) the weather was dry; however the previous days had seen moderate rainfall events which had followed a period of dry weather.

At the time of sampling stream 4 was inaccessible due to an overgrown hedge. However it has been noted that the open water section of stream 4 is located at a distance well beyond the reaches of the Proposed Improvement. Stream 4 will be used as at present to carry runoff from the proposed carriageway surface water channels draining the carriageway over a length of 300m, in which filter drains along the southern boundary of the road discharge into the carriageway network system 6. A new drain will be piped directly into the existing culvert to discharge runoff from the carriageway drainage network.

Stream 3 was also dry during the first set of sampling, using the sample bottle for stream 3 a sample was taken from stream 7downstream of the A55(T). This was done to gain an understanding of the downstream characteristics of the stream to establish the current conditions downstream of the A55(T) within an undeveloped field.

Sample set 2:
On the day of sampling (11/11/15) there was intermittent rainfall following 3-4 days of heavy rainfall. It was noticed that flows in each of the streams (except stream 4) were significantly higher than the previous samples.

<u>Note</u>
Although there are no data held on stream 4, it is not expected that there will be adverse effects on the watercourse as it is located at a suitable distance from the A55(T), and the

new pipe will be fitted with a filter to ensure that pollution and increased sedimentation does not occur. The Proposed Improvement will not upsize the road capacity to allow for increased volumes of traffic, therefore it is not expected that increases in hydrocarbons will occur.

3.8 Characteristics and elements analysed

Zinc

The natural zinc content of soils is estimated to be 1-300 mg/kg. In natural surface waters, the concentration of zinc is usually below 10 µg/ litre, and in groundwater, 10-40 µg/litre. In tap water the zinc concentration can be much higher as a result of the leaching of zinc from piping and fittings.

Sample 1.

Sample Number		1	2	3	4	5	6	US of 7	DS of 7	8
Type		Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water
Zinc, Total as Zn	mg/l	<0.018	0.05	N/S	N/S	<0.018	<0.018	<0.018	<0.018	<0.018

Sample 2.

Sample Number		1	2	3	4	5	6	7	8
Type		Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water
Zinc, Total as Zn	mg/l	<0.018	<0.018	<0.018	N/S	<0.018	<0.018	<0.018	<0.018

Of the sampled streams all except stream 2 contained less than 0.018 mg/l of Zinc (18 µg/l) which is within the natural surface water levels. The 0.05 mg/l of zinc found in water sample 2 of the first set of samples is five times the normal concentration of zinc in surface waters. However the second set of samples indicate that <0.018mg/l of zinc was found in the stream. Therefore it is possible to conclude that zinc contamination is not of threat to the water quality. Monitoring of the zinc levels of this stream will be able to establish if there is a trend in zinc concentrations for this stream.

pH

Freshwater lakes, ponds and streams usually have a pH of 6-8 depending on the surrounding soil and bedrock. Low levels of pH can encourage the solubility of heavy metals. As the level of hydrogen ions increases, metal cations such as aluminium, lead, copper and cadmium are released into the water instead of being absorbed into sediment. High pH levels can damage gills and skin of aquatic organisms.

Sample 1.

Sample Number		1	2	3	4	5	6	US of 7	DS of 7	8
Type		Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water
pH	pH units	8	7.8	N/S	N/S	7.4	7.4	8	7.9	7.5

Sample 2.

Sample Number		1	2	3	4	5	6	7	8
Type		Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water
pH	pH units	7.5	7.4	7.4	N/S	6.9	6.9	7.6	7.4

Sample set 1 gave pH values of between 7.4 and 8 illustrating slightly alkali soil, this could be due to fertiliser contamination from the surrounding fields. Following onto sample set 2 the pH levels of the streams have altered. The samples have shown a trend of lower pH during the second sampling. This may have been due to the heavy rainfall events. Rainfall is slightly acidic due to its mixing with CO2 in the atmosphere before it reaches the ground surface. Combined with the acidic soils of the area, the saturated ground will result in increased ground water flowing into the river which may be of a more acidic pH and therefore altering the natural pH of the watercourse. All of the sampled streams showed levels of pH that were within the norms of surface water. The pH levels analysed provide a suitable habitat for aquatic life and illustrate water of potential drinking quality in regards to pH level.

Electrical Conductivity (EC)

Electrical conductivity is a good indicator of the total salinity; it still does not provide any information about the ion composition in the water. The EC is a measure to the capacity of water to conduct electrical current, it is directly related to the concentration of salts dissolved in water, and therefore to the Total Dissolved Salts (TDS). Salts dissolve into positively charged ions and negatively charged ions, which conduct electricity.

Sample 1.

Sample Number		1	2	3	4	5	6	US of 7	DS of 7	8
Type		Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water
Conductivity-Electrical 20C	µS/cm	175	213	N/S	N/S	80.6	95.7	201	207	97.5

Sample 2.

Sample Number		1	2	3	4	5	6	7	8
Type		Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water
Conductivity-Electrical 20C	µS/cm	182	193	177	N/S	77.9	93.6	171	194

The electrical conductivity results for the sampled streams would indicate normal stream EC levels. The EC varies between the streams with a range from 80.6 µS/cm to 213 µS/cm. The EC indicated the Total Dissolved Salts. Therefore the higher the EC it can be estimated the higher the concentration of dissolved salts. The EC does not give any indication of the type of salts dissolved in the stream, just an indication of the concentration of the dissolved salts.

Turbidity

Turbidity is the measure of relative clarity of a liquid. It is an optical characteristic of water and is an expression of the amount of light that is scattered by material in the water when light is shined through the sample. The higher the intensity of scattered light, the higher the turbidity. Material that causes water to be turbid includes clay, silt, finely drained inorganic and organic compounds, plankton and other microscopic organisms.

During periods of low flow (base flow), many rivers are clear green in colour, and turbidities are low, usually less than 10 NTU (nephelometric turbidity units). During a rainstorm, particles from the surrounding land are washed into the river making the water a muddy brown colour, indicating water that has a higher turbidity. High concentrations of particulate matter affect light penetration and productivity, recreational values and habitat quality.

In streams, increased sedimentation and siltation can occur, which can result in harm to habitat areas for fish and other aquatic life. Particles can provide attachment places for other pollutants, notably metals and bacteria. For this reason, turbidity readings can be used as an indicator of potential pollution in a water body. Turbidity can provide food and shelter for pathogens. If not removed, turbidity can promote regrowth of pathogens in the distribution system, leading to waterborne disease outbreak.

Sample 1.

Sample Number		1	2	3	4	5	6	US of 7	DS of 7	8
Type		Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water
Turbidity	NTU	1.58	9.59	N/S	N/S	3.32	9.05	6.23	16.4	8.46

Sample 2.

Sample Number		1	2	3	4	5	6	7	8
Type		Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water
Turbidity	NTU	9.5	4.45	8.12	N/S	2.87	4.95	7.54	12.8

Stream 7 was the only stream to show turbidity above 10 NTU (16.4 NTU). The remaining streams all showed values below 10 NTU indicative of turbidities of low flow streams.

Stream 7 was downstream of the A55(T) within a field used to rear livestock giving indication that the stream is susceptible to sedimentation.

Extractable Hydrocarbons (EH)

Petroleum does not contain just one single compound, but many hundreds of compounds, all based on the chemistry of carbon and hydrogen. Some compounds contained in petroleum are more harmful than others.

Sample 1.

Sample Number		1	2	3	4	5	6	US of 7	DS of 7	8
Type		Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water
EH >C24 - C40	µg/l	10	15	N/S	N/S	<10	<10	36	18	<10

Sample 2.

Sample Number		1	2	3	4	5	6	7	8
Type		Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water
EH >C24 - C40	µg/l	<10	<10	<10	N/S	<10	<10	<10	22

The sampled streams do not indicate high levels of pollution from hydrocarbons with the highest recorded value of 36 µg/l for EH> C24- C40 (Heavy fuel oils, lubricating oils, heating and related products or asphalts and pitch) during sample set 1. The dilution of the hydrocarbons is likely to have been caused by the heavy rainfall before Sample 2. The dilution indicates that the streams are recipient of unpolluted 'clean' water which will enable the streams to be refreshed and any pollution to be diluted and 'washed out'.

Chart 3-5 below indicated the various fuel types linked to the carbon level shown in the results table above.

From analysis of all the streams the highest concentration of hydrocarbons was the C24-C40 type- heavy fuel oils, lubricating oils, heating and related products or asphalts and pitch.

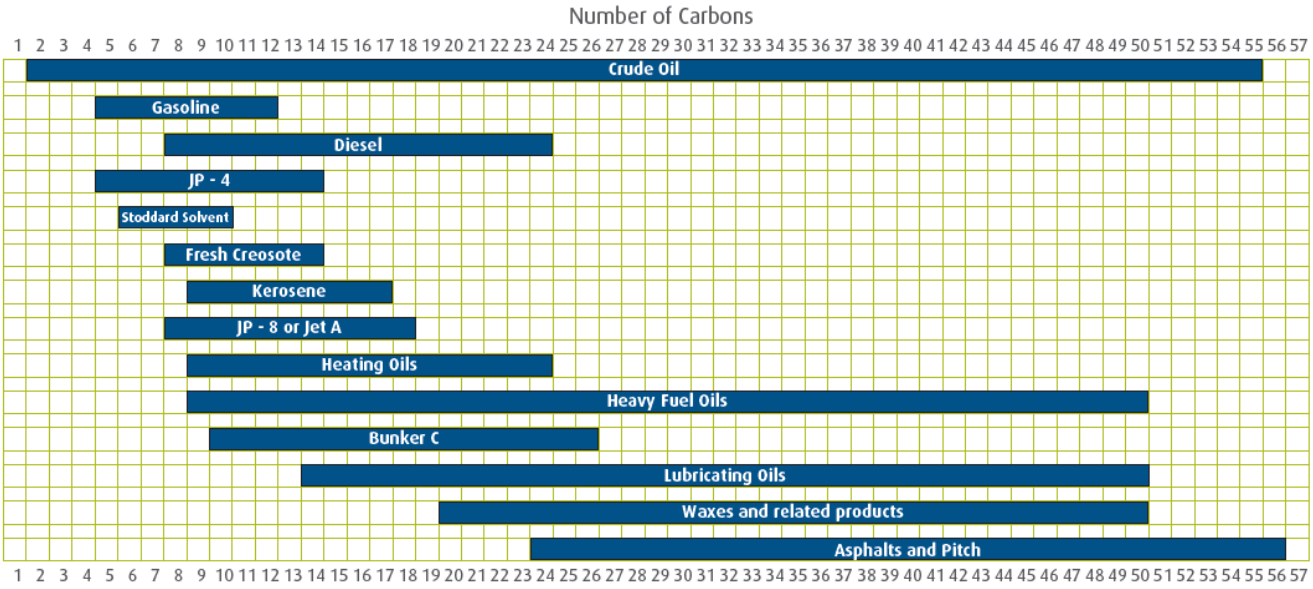
The Environmental Protection Agency has classified seven Polycyclic Aromatic Hydrocarbons (PAH) compounds as probable human carcinogens: *benz[a]anthracene*, *benzo[a]pyrene,benzo[b]fluoranthene,benzo[k]fluoranthene,chrysene,dibenz(a,h)anthracene*, and *indeno(1,2,3-cd)pyrene.* Chart 3-5 illustrates the other hydrocarbons that could be found within water. C24- C40 hydrocarbons had the most significant readings from the water samples.

Polycyclic aromatic hydrocarbons (PAHs)
Found in drinking water where coal tar lining of mains was historically practiced to prevent corrosion. The standard is a measure of benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene and indeno(1,2,3-cd)pyrene. Max concentration permitted in surface water = 0.1µg/l.

Benzene
Used in the petrochemical and plastics industry. Occasionally it is found in source water but is removed by treatment. Max concentration permitted in surface water = 1µg/l.

Benzo(a)pyrene
One of several compounds known as polycyclic aromatic hydrocarbons. Trace levels can be found in drinking water where coal tar lining of mains was historically practiced to prevent corrosion. Max concentration permitted in surface water = 0.01µg/l.

Chart 3-5: Petroleum Fractions by Carbon Range



Total Suspended Solids

In stream water, dissolved solids consist of calcium, chlorides, nitrate, phosphorous, iron, sulphur and other ion particles. The concentration of total dissolved solids affects the water balance in the cells of aquatic organisms. Higher concentration of total suspended solids can serve as carriers of toxics such as dissolved metals and pathogens, which readily cling to suspended particles. This is particularly a concern where particles are being used on irrigated crops, where solids are high, pesticide concentrations may increase. Higher solids decrease the passage of light through water, thereby slowing photosynthesis by aquatic plants. Water will heat up more rapidly and hold more heat; this in turn may adversely affect aquatic life.

Sources of total solids include industrial discharges, sewage, fertilizers, road runoff and soil erosion. Total solids measurements can be useful as an indicator of the effects of run off from construction, agricultural practices, logging activities, sewage treatment plant discharges etc.

As with turbidity, concentrations often increase sharply during rainfall. Regular monitoring of total solids can help detect trends that might indicate increasing erosion in developing watersheds. Total solids are related closely to stream flow and velocity and should be correlated with these factors.

Sample 1.

Sample		1	2	3	4	5	6	US of 7	DS of 7	8

Number										
Type		Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water
Total Suspended Solids	mg/l	2	19	N/S	N/S	10	20	11	30	14

Sample 2.

Sample Number		1	2	3	4	5	6	7	8
Type		Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water
Total Suspended Solids	mg/l	12	6	12	N/S	5	6	14	24

DS of Stream 7 has the greatest recording for total suspended solids, with 30 mg/l during sample set 1, indicative that the sample was taken downstream in unmaintained field drainage with high levels of siltation and sedimentation. At the time of sampling the stream was not fast flowing and had a number of slow moving pools of water. The greater the TSS, the greater the chance of algal blooms or waterborne outbreaks occurring. The levels of TSS for all eight streams illustrates that the suspended soils level varies depending on the subsequent weather, therefore the sediment is not stagnant within the streams and a build-up of suspended sediment is less likely to occur.

4.0 Summary of results and findings

Water Quality

The level of pollution seen in the results does not indicate that the streams are receiving high levels of pollution from the surrounding land. The level of zinc within the water is of an acceptable level within the normal parameters for zinc levels in surface water bodies. The turbidity and levels of total solids at the time of sampling can be for a number of reasons. The time of sampling occurred shortly after rainfall events, which could have led to increased movement of sediment which had yet to settle, and secondly due to the nature of the locations of the streams, higher levels of solids and turbidity are expected as they are within a rural setting (fields) where there is presence of livestock.

The presence of hydrocarbons within the watercourses indicates their close proximity to the A55 (T). Although the Proposed Improvement will require increasing the footprint of the road surface, the improvements are to comply with current standards and not to increase traffic volumes along the A55(T). It can therefore be estimated that the improvement works will not adversely affect the watercourses within the Proposed Improvement section, if best working

standards, practice and care is taken to ensure that there is no leaching of materials during construction.

From the results of the second stage of water samples it is estimated that the water quality is of good or high status following the WFD guidelines Table 4-0 summaries the water quality status for the 2015 samples and their related objective and updates tables 3-1 and 3-2[4]. The Proposed Improvement is not being designed to increased traffic volume, however the overall footprint of the impermeable surface and increased drainage will require proper regulation and design to ensure that increased levels of pollution, especially hydrocarbons, do not enter the watercourses. The Proposed Improvement is not expected to increase pollution levels or have adverse effects on the watercourses within the Proposed Improvement area, therefore no further WFD assessment needs to be carried out.

Table 1.4 Summary of the overall WFD status and objectives for the 2015 water samples.

Name of catchment	Streams Present	Type of catchment	Ecological Classification	Overall Objective
Un-named to	1,2 & 3	Mid, Extra Small, Siliceous	Moderate	Good Status by 2027
Un-named	4	Low, Extra Small, Siliceous	Moderate	Good Status by 2027
Afon Wig	5	Low, Extra Small, Siliceous	Moderate	Good Status by 2027
Un-named	6, 7 & 8	Mid, Small, Siliceous	Moderate	Good Status by 2015

It should be noted that best working practices will be carried out during construction to ensure that spillages and contamination does not occur. The watercourses will be monitored through the construction and post construction phases and water samples will be analysed to identify whether contamination or adverse impacts have occurred.

Hydromorphology and hydrogeomorphology

Changes to hydromorphology and hydrogeomorphology can be significant with loss of drainage channels to culverting and increases to flow rates. Mitigation measures such as baffle weirs to dissipate energy, river training walls to ensure the river geometry is retained and weirs are proposed as part of the Proposed Improvement.

[4] Note that no change in water quality has occurred since the 2006/07 samples. Pollution to the streams within the Proposed Improvement are not exposed to high levels of pollution or contamination from the A55(T) or the surrounding fields.

The main source of channel loss and changes to hydromorphology and hydrogeomorphology within the Proposed Improvement is to culvert extensions. The table below highlights the culvert extension lengths to each watercourse and the total percentage of the watercourse that is lost to culvert extensions. Where culvert extensions have been incorporated into the natural stream, suitable mitigation measures will be included to reduce velocity rates.

Table 1.5 Culvert extensions required for the Proposed Improvement

Stream	Culvert Extension North (km)	Culvert Extension South (km)	Total culvert extension length (km)	Total watercourse length (km)	% of watercourse with extended culvert
1	0.01000	No extension	0.01000	3.65	0.27
2	0.01146	No extension	0.01146	2.4	0.48
3	0.00880	No extension	0.00880	2.9	0.30
4	0.00656	0.00503	0.01157	1.3	0.89
5	0.001162	0.0053	0.00646	8.37	0.077
6	0.00723	0.0061	0.01333	2.19	0.61
7	0.01079	0.0147	0.02550	0.99	2.58
8	0.00536	0.0023	0.00766	0.95	0.806

Stream 8 will be lined using a geotextile material that will replicate the natural stream channel and bed. The stream material will be reused and placed on-top of the lining to recreate a natural environment. Due to the current high rates of erosion within stream 8, the lining is proposed as a positive erosion prevention measure. Therefore the changes to the hydromorphology and hydrogeomorphology of stream 8 is seen to be positive.

There will be no other significant changes or alterations to stream hydromorphology or hydrogeomorphology during the construction or operational phases of the Proposed Improvement.

5.0 Appendices

Appendix 1- List of Abbreviations used in this document
Appendix 2. Location and extent of the Proposed Improvement Scheme
Appendix 3 Summary of previous water samples from 2006/ 2007
Appendix 4- Summary of the 2015 water samples

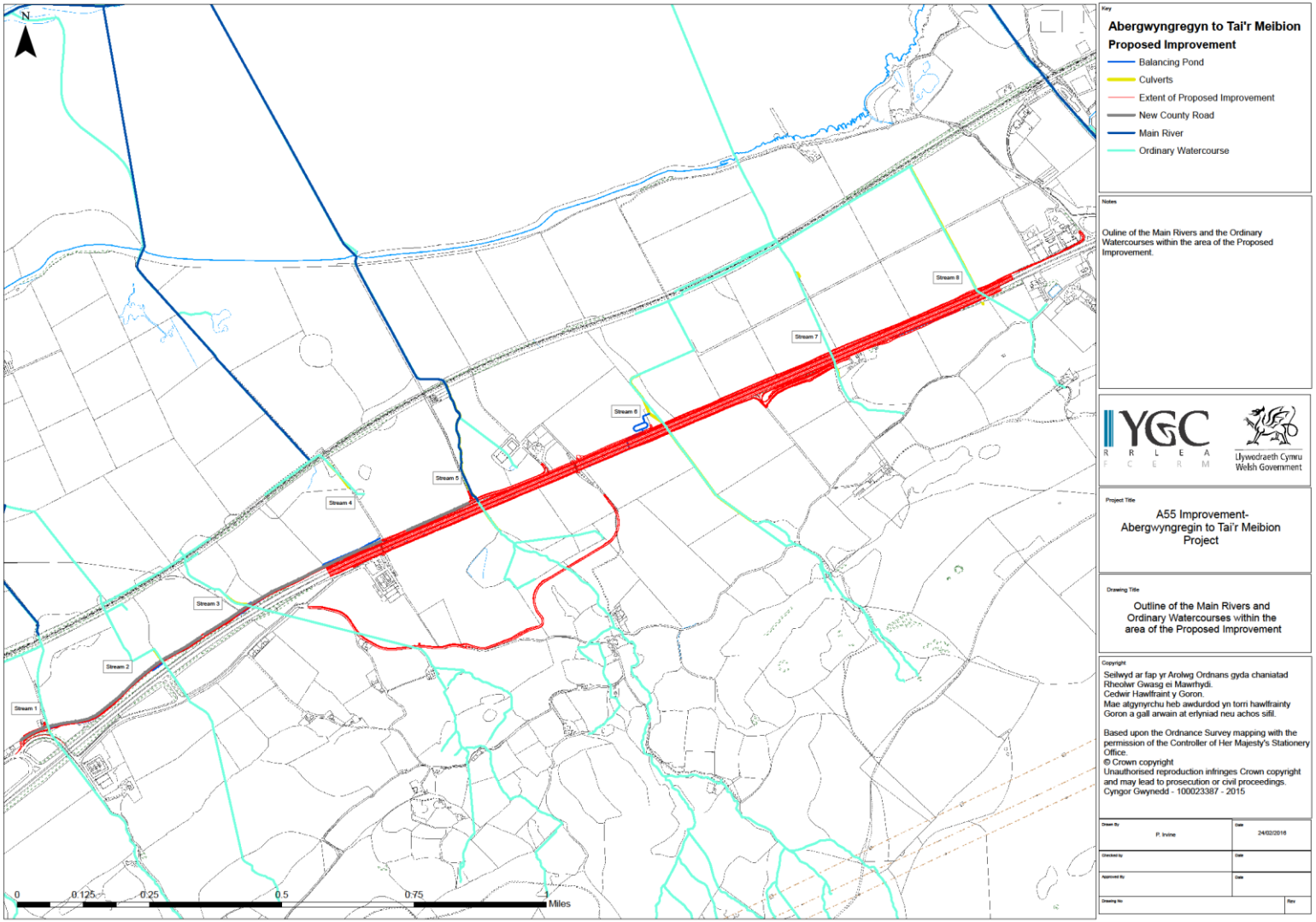
Appendix 1- List of Abbreviations used in this document

This chapter provides a summarised reference list of the abbreviations that have been used in this document.

AADT	Annual Average Daily Traffic
CC	Climate Change
CIRIA	Construction Industry Research & Information Association
DMRB	Design Manual for Roads and Bridges
DS	Downstream
E/B	Eastbound
EC	Electrical Conductivity

EQS	Environmental Quality Standards
EU	European Union
FCA	Flood Consequence Assessment
GEP	Good Ecological Potential
GES	Good Ecological Status
GQA	General Quality Assessment
HAWRAT	Highways Agency Water Risk Assessment Tool
MH	Manhole
NGR	National Grid Reference
NMU	Non-motorised User
NMWTRA	North and Mid Wales Trunk Road Agent
NNR	National Nature Reserve
NRW	Natural Resources Wales
N/S	No Sample
NTU	Nephelometric Turbidity Units
PAH's	Polycyclic Aromatic Hydrocarbons
PMA	Private Means of Access
PPG	Pollution Prevention Guideline
PPW	Planning Policy Wales
Q95	Flow in cubic metres per second which was equalled or exceeded for 95% of the flow record. The Q95 flow is a significant low flow parameter particularly relevant in the assessment of river water quality consent conditions.
RBMP	River Basin Management Plan
SAC	Special Area of Conservation
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
SuDS	Sustainable Drainage System
SW	Surface Water
TAN	Technical Advice Note
TDS	Total Dissolved Salts
TSS	Total Suspended Solids
US	Upstream
W/B	Westbound
WFD	Water Framework Directive (2000/60/EC)

Appendix 2- Location and extent of the Proposed Improvement



Appendix 3- Summary of previous water samples from 2006/2007

No.	Dissolved Oxygen (% saturation) 10 Percentile	Biochemical Oxygen Demand (mg/l) 90 Percentile	Total Ammonia (mg N/L) 90 Percentile	Un-ionized Ammonia (mg N/L) 95 Percentile	pH	Hardness Magnesium in CaCo3 (mg/l)	Hardness Calcium in CaCo3 (mg/l)	Dissolved copper (µg/l) 95 Percentile	Total zinc (µg/l) 95 Percentile	Ammonia as NH_3 Calculated	Temp °C	Date
Stream 1												
1DS	8.9	n/a	n/a	n/a	6	179	n/a	200	420	-0.04	n/a	24/4/07
1DS	10.9	n/a	n/a	n/a	6	149	n/a	10	240	0.06	n/a	08/5/07
1DS	10.2	n/a	n/a	n/a	6.5	165	n/a	100	500	-0.00	n/a	23/5/07
1DS	10.1	n/a	n/a	n/a	7	170	n/a	30	40	0.06	n/a	06/6/07
Avg. Stream 1	10.03	n/a	n/a	n/a	6.38	165.75	n/a	85	300	0.02	n/a	
Stream 2												
2US*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	24/4/07
2US*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	08/5/07
2US*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	23/5/07
2US*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	06/6/07
Avg	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
2DS	9.8	n/a	n/a	n/a	6	140	0.02	10	520	0.2	n/a	24/4/07
2DS	10.9	n/a	n/a	n/a	6	155	-0.05	10	780	0.1	n/a	08/5/07
2DS	9.5	n/a	n/a	n/a	6.5	176	0.0	100	90	0.02	n/a	23/5/07
2DS	9.8	n/a	n/a	n/a	6.5	165	n/a	-40	380	0.03	n/a	06/6/07
Avg	10	n/a	n/a	n/a	6.25	159	-0.01	20	442.50	0.09	n/a	
Avg Stream 2	10	n/a	n/a	n/a	6.25	159	-0.01	20	442.50	0.09	n/a	
Stream 3												
3DS	10.4	n/a	n/a	n/a	6.5	29	0.05	150	160	0.5	n/a	24/4/07
3DS	9.6	n/a	n/a	n/a	7	6	0.12	220	960	0.12	n/a	08/5/07
3DS*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	23/5/07
3DS*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	06/6/07
Avg Stream 3	10	n/a	n/a	n/a	6.75	17.5	0.09	185	560	0.31	n/a	
Stream 5												

No.	Dissolved Oxygen (% saturation) 10 Percentile	Biochemical Oxygen Demand (mg/l) 90 Percentile	Total Ammonia (mg N/L) 90 Percentile	Un-ionized Ammonia (mg N/L) 95 Percentile	pH	Hardness Magnesium in CaCo3 (mg/l)	Hardness Calcium in CaCo3 (mg/l)	Dissolved copper (µg/l) 95 Percentile	Total zinc (µg/l) 95 Percentile	Ammonia as NH_3 Calculated	Temp °C	Date
5US	5.8**	<1	<0.3	<0.04	8	-	32.4 mg/l total as Ca	<5	1	<0.4	n/a	13/6/06
5US	9.4	n/a	0.05	n/a	7	153 mg/l	-0.05	0	3	n/a	n/a	20/6/06
5US	9.7	n/a	-0.5	n/a	7	162 mg/l	Under range	0	2	n/a	12.4	28/6/06
5US	9.9	n/a	0.08	n/a	7	184 mg/l	0.13	2	Over range	n/a	14.3	04/7/06
Avg	9.67	<1	<0.3	<0.04	7.25	166.3 mg/l	n/a	2 µg/l	2.0 µg/l	n/a	13.4	
5DS	7.1**	<1	<0.3	<0.04	8.1	-	30.6 mg/l total as Ca	<5	1	<0.4	n/a	13/6/06
5DS	10.3	n/a	0.03	n/a	7	191 mg/l	0.10 ppm CaCO3	1	3	n/a	n/a	20/6/06
5DS	10.9	n/a	-0.6	n/a	7	153 mg/l	Under range	1	2	n/a	12.5	28/6/06
5DS	10.7	n/a	0.14	n/a	7	179 mg/l	0.08	6	Over range	n/a	14.2	04/7/06
Avg	10.63	<1	<0.3	<0.04	7.27	174.3 mg/l	n/a	8 µg/l	2.0 µg/l	n/a	13.4	
Avg Stream 5	10.15 (96%)	<1	n/a	<0.04	7.3	170.3 mg/l	n/a	5.0 µg/l	2.0 µg/l	n/a	13.4	
Stream 6												
6US	4.9**	<1	<0.3	<0.04	8.2	-	11.9 mg/l total as Ca	<5	1	<0.4	n/a	13/6/06
6US	10.2	n/a	0.01	n/a	7	182 mg/l	Under range	8	2	n/a	n/a	20/6/06
6US	9.5	n/a	-0.3	n/a	7	181 mg/l	0.01	2	2	n/a	13.3	28/6/06
6US	8.8	n/a	0.12	n/a	6.5	159 mg/l	0.12	1	Over range	n/a	17.2	04/7/06
Avg	9.5	<1	<0.3	<0.04	7.18	174 mg/l	n/a	3.7 µg/l	1.7 µg/l	n/a	15.3	
6DS	3.9**	<1	<0.3	<0.04	7.6	-	12.5 mg/l total as Ca	<5	1	<0.4	n/a	13/6/06
6DS	10	n/a	0.01	n/a	7	200 mg/l	Under range	6	3	n/a	n/a	20/6/06
6DS	10.5	n/a	-0.8	n/a	7	177 mg/l	Under range	<1	5	n/a	13	28/6/06
6DS	8.6	n/a	0.05	n/a	6.5	197 mg/l	Under range	7	Over range	n/a	17.4	04/7/06
Avg	9.7	<1	<0.3	<0.04	7.01	191.3 mg/l	n/a	4.7 µg/l	3.0 µg/l	n/a	15.2	
Avg Stream	9.6 (95%)	<1	<0.3	<0.04	7.1	182.7 mg/l	n/a	4.2 µg/l	2.4 µg/l	n/a	15.25	

No.	Dissolved Oxygen (% saturation) 10 Percentile	Biochemical Oxygen Demand (mg/l) 90 Percentile	Total Ammonia (mg N/L) 90 Percentile	Un-ionized Ammonia (mg N/L) 95 Percentile	pH	Hardness Magnesium in CaCo3 (mg/l)	Hardness Calcium in CaCo3 (mg/l)	Dissolved copper (µg/l) 95 Percentile	Total zinc (µg/l) 95 Percentile	Ammonia as NH_3 Calculated	Temp °C	Date
6												
Stream 7												
7US	4.6**	<1	<0.3	<0.04	7.8	-	9.8 mg/l total as Ca	<5	2	<0.4	n/a	13/6/06
7US	11.1	n/a	0.02	n/a	7	190 mg/l	Under range	3	6	n/a	n/a	20/6/06
7US	10	n/a	Under range	n/a	6	173 mg/l	-0.01	2	3	n/a	12	28/6/06
7US	9.2	n/a	Under range	n/a	6.5	203 mg/l	Under range	5	Over range	n/a	14.7	04/7/06
Avg	10.1	<1	<0.3	<0.04	6.8	188.7 mg/l	n/a	3.3 µg/l	3.7 µg/l	n/a	13.4	
7DS	5.3**	<1	<0.3	<0.04	7.7	-	9.9 mg/l total as Ca	<5	1	<0.4	n/a	13/6/06
7DS	10.1	n/a	0.01	n/a	7	167 mg/l	Under range	1	4	n/a	n/a	20/6/06
7DS	10	n/a	Under range	n/a	6	171 mg/l	0.03	1	0	n/a	12.1	28/6/06
7DS	9.1	n/a	0.06	n/a	6.5	167 mg/l	Under range	6	Over range	n/a	14.8	04/7/06
Avg	9.73	<1	<0.3	<0.04	6.8	168.3 mg/l	n/a	2.7 µg/l	3.0 µg/l	n/a	13.5	
Avg Stream 7	9.92 (86%)	<1	<0.3	<0.04	6.8	178.5 mg/l	n/a	3.0 µg/l	3.35 µg/l	n/a	13.45	

Appendix 4- Summary of the 2015 water samples

Sample set 1 (5/11/15)

Sample Number		**1**	**2**	**3**	**4**	**5**	**6**	**US of 7**	**DS of 7**	**8**
Type		SW*	SW	SW	SW	SW	SW	SW	SW	SW
Analyte	Units			**Dry**	**No access**					
Zinc, Total as Zn	mg/l	<0.018	0.05	N/S	N/S	<0.018	<0.018	<0.018	<0.018	<0.018
pH	pH units	8	7.8	N/S	N/S	7.4	7.4	8	7.9	7.5
Conductivity-Electrical 20C	µS/cm	175	213	N/S	N/S	80.6	95.7	201	207	97.5
Turbidity	NTU	1.58	9.59	N/S	N/S	3.32	9.05	6.23	16.4	8.46
Total Suspended Solids	mg/l	2	19	N/S	N/S	10	20	11	30	14
EH >C6 - C40	µg/l	10	15	N/S	N/S	<10	<10	36	18	<10
EH >C6 - C8	µg/l	<10	<10	N/S	N/S	<10	<10	<10	<10	<10
EH >C8 - C10	µg/l	<10	<10	N/S	N/S	<10	<10	<10	<10	<10
EH >C16 - C24	µg/l	<10	<10	N/S	N/S	<10	<10	<10	<10	<10
EH >C24 - C40	µg/l	10	15	N/S	N/S	<10	<10	36	18	<10
EH >C10 - C16	µg/l	<10	<10	N/S	N/S	<10	<10	<10	<10	<10
Visible Oil	None	None	None	N/S	N/S	None	None	None	None	None

***SW= Surface Water**

Sample set 2 (11/11/15)

Sample Number		1	2	3	4	5	6	7	8
Type		SW	SW	SW	SW	SW	SW	SW	SW
Analyte	Units				**No access**				
Zinc, Total as Zn	mg/l	<0.018	<0.018	<0.018	N/S	<0.018	<0.018	<0.018	<0.018
pH	pH units	7.5	7.4	7.4	N/S	6.9	6.9	7.6	7.4
Conductivity-Electrical 20C	µS/cm	182	193	177	N/S	77.9	93.6	171	194
Turbidity	NTU	9.5	4.45	8.12	N/S	2.87	4.95	7.54	12.8
Total Suspended Solids	mg/l	12	6	12	N/S	5	6	14	24
EH >C6 - C40	µg/l	<10	<10	<10	N/S	<10	<10	<10	22
EH >C6 - C8	µg/l	<10	<10	<10	N/S	<10	<10	<10	<10
EH >C8 - C10	µg/l	<10	<10	<10	N/S	<10	<10	<10	<10
EH >C16 - C24	µg/l	<10	<10	<10	N/S	<10	<10	<10	<10
EH >C24 - C40	µg/l	<10	<10	<10	N/S	<10	<10	<10	22
EH >C10 - C16	µg/l	<10	<10	<10	N/S	<10	<10	<10	<10
Visible Oil	None	None	None	None	N/S	None	None	None	None

***SW= Surface Water**

A55(T) Abergwyngregyn to Tai'r Meibion Improvement

DRAINAGE STRATEGY

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WELSH GOVERNMENT

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Revision History

Date	Version No.	Summary of Changes
10/11/2015	0.01	
29/07/2016	0.02	
27/10/2016	0.03	

Approvals

Approved by	Signature	Date	Version
Rob Williams		02/06/2016	0.01
Rob Williams		27/10/2016	0.02

Distribution

Name	Title	Date	Version

ISO9001:2008 FS526386 | ISO14001:2004 EMS 526388 | OHSAS18001:2007 OHS 526389

CONTENTS

EXECUTIVE SUMMARY

This document provides a summary of the key elements of the outline drainage design principles to be used on the A55 (T) Abergwyngregyn to Tai'r Meibion Proposed Improvement.

The report is intended for the use of Welsh Government, NMWTRA, NRW, LLFA, operating agencies and the contractor.

Carriageway drainage would be provided by a kerb and gulley system along sections of embankment and filter drains in cuttings. The latter would capture carriageway runoff and a portion of the cutting drainage.

Drainage for the new county road would comprise of a kerb and gully system with online flow controls to limit the discharge rates by a third of the hard surface runoff.

Carriageway drainage capacities would be designed to achieve no surcharge during a 100% (1 in 1) annual average chance event and no flooding during 20% (1 in 5) annual chance event, with no flooding during a 33% (1 in 30) annual chance event in critical areas.

Attenuation facilities in the form of a detention pond with flow controls would restrict the discharge rates to no more than the pre-development Greenfield run-off. These would be designated to contain the volume of runoff from a 1% (1 in 100) annual chance event inclusive of a climate change allowance.

The detention pond would incorporate settlement fore bays and vegetative treatment areas, and would serve the dual purpose of pollution control and flow control. The pond would be equipped with skim plates and flow controls which would operate on the same principles as oil separators. Shut-off valves would be provided at pond outlets to contain accidental spillages.

Further pollution control measures would be offered by filter drains where provided.

Access for future maintenance would be provided to all attenuation, pollution control and outfall facilities as appropriate.

Fence line drains would be predominantly configurations of a bund and ditches lined with trapezoidal pre cast concrete channels. These would be designed to a 1.33% (1in 75) annual chance event capacity.

1. The Project

1.1. Background information

The Proposed Improvement (see Figure 1, Volume 1a) is located on the A55(T) approximately 6.5km (4 miles) east of Bangor and west of Abergwyngregyn and runs parallel with the main London to Holyhead railway, south of the Menai Strait. It is approximately 600m south of Traeth Lafan, which is part of a Special Area of Conservation (SAC) and Special Protection Area (SPA) and approximately 40m north (at its closest point) of the Snowdonia National Park.

The A55(T) Chester to Bangor Trunk Road is an important strategic transport route in North Wales forming a link between the ferry port of Holyhead and the motorway system in Cheshire and Merseyside. It also serves numerous settlements along the North Wales Coast, providing a route for commercial, tourist and local traffic.

Under the United Nations Agreement of 1975 on international traffic arteries, the A55(T) forms part of the 5,320km Euroroute E22 between Holyhead, Wales and Ishim, Russia. The route is of international importance for commercial vehicles travelling through Continental Europe and the United Kingdom, and the continuing improvement of the highway network is hence vital for the ongoing economic development and social well-being of the area.

The Welsh Government has statutory powers and responsibility for the maintenance and improvement of the A55(T). The section of the A55(T) between Tai'r Meibion and Abergwyngregyn was one of the first to be improved to dual carriageway standards in the late 1960's and now does not comply with current highway standards. The document 'Driving Wales Forward' (The Welsh Office, 1998) identified the A55(T) as part of the core network in Wales and recognised a lack of safe turning arrangements and bus lay-by provisions between Tal y Bont and Abergwyngregyn.

When the issue of re-construction of the highway pavement initially arose the work was to be undertaken under the Welsh Government's Major Maintenance Programme. However, as the scheme was being developed it was decided that a full upgrade was required to bring the section up to the same standards as the remainder of the A55(T). The work was therefore re-designated as an 'improvement' and included in the Welsh Government's Trunk Road Forward Programme, which is to be updated by the forthcoming National Transport Plan. See Section 2.3 for further information on the policy context in support of the need for the Proposed Improvement.

1.2. Justification in relation to relevant policies and plans and the Project objectives

General Design and Construction.
This section of the A55(T) is now around 45 years old and the vertical alignment, although originally designed to standards current at the time, does not comply with the present-day standards to which the adjacent sections have been built. The existing forward visibility distances are significantly below current requirements and the central reserve gaps, private entrances, field accesses and junction to the county road are often used by slow-moving vehicles, which is a detriment to the free and safe flow of through traffic on the A55(T). The Proposed Improvement would aim to address these deficiencies.

Existing Carriageway.
The 2.2km length of existing A55(T) to be improved commences west of the property known as Tai'r Meibion farm. The existing alignment follows a south-westerly – north-easterly route and consists of dual two-lane 7.3m wide carriageways with grass verges, but no hard strips. The eastbound and westbound carriageways are segregated by a 4.5m wide grassed central reserve. The horizontal alignment is relatively straight whilst the vertical alignment undulates with sub-standard forward visibility in places. The channels on both carriageways are kerbed on both sides whilst the grass verges vary in width with an average of 2.5m. After many years of interim maintenance the residual life of the westbound carriageway pavement in particular is considered to be low.

A county road, 11 field accesses, two farm accesses, two domestic accesses and one combined farm and domestic access all link directly onto the A55(T) dual carriageway. None of the accesses have merge/diverge lanes and most have restricted visibility. Eight gaps in the central reservation allow vehicles to drive through and change direction of travel. Most of these are located near field accesses and junctions with private means of access, allowing vehicles to make right turn movements across the path of oncoming vehicles. There are currently no restrictions in place to prohibit such traffic movements.

There are several cross-carriageway culverts of varying diameters along the scheme length. These culverts take the carriageway surface water drainage and adjacent watercourses under the A55(T) eventually discharging into the western end of Conwy Bay in the Menai Strait at Traeth Lafan. Two of these culverts, 1) carrying stream 5 and 2) stream 8 are deemed to be substandard as they do not provide enough capacity for their respective streams. The culvert carrying stream 5 will be upsized from a 1050mm diameter pipe to a 3.6m^2 culvert including wildlife passage. The culvert carrying stream 8 will be upsized from a 300mm diameter pipe to a 1200mm diameter pipe**.**

The Proposed Improvement is situated in a rural area with no viable alternative east –west local route. Roman (Henffordd) Road runs east–west to the south of the A55(T), but this is considered too narrow and unsuitable to accommodate large numbers of vehicles. Therefore, vehicles are not expected to transfer to the improved section from another route in the locality, nor are travellers expected to change their mode of transport.

2. Purpose of the report

The purpose of this report is to describe the proposed design strategy for key elements of the new road drainage system. It covers the design standards to be adopted, as well as levels of service and methods of analysis as appropriate.

The report is intended for the use of;

- The Welsh Government and North and Mid Wales Trunk Road Agent in determination of acceptability of the chosen design

- Natural Resources Wales for the purpose of agreement on design principles in relation to flood defence applications.

- Gwynedd Council as Lead Local Flood Authority (LLFA)

- The contractor for assistance in construction strategy and development of target costs.

3. Existing & Proposed Drainage Works

3.1. Proposed Highway Works

The works are as described in detail in Section 1.2 above. Please refer to Appendix B for a list of drainage drawings to be read in conjunction to this report.

In brief,

- The Proposed Improvement involves on-line improvements to a relatively straight section of dual carriageway and as such there are no viable alternative horizontal alignments. The western extent of the highway improvement section commences opposite Tai'r Meibion farm and continues eastwards to terminate approximately 300m south-west of the Abergwyngregyn interchange eastbound slip road (Junction 13).

- The length of the carriageway improvement is approximately 2.2km and consists of dual 7.3m wide two-lane carriageways with minimum 1.0m wide hard strips each side and a 2.5m wide verge beyond, giving at least 3.5m of relatively flat area beyond the edge of carriageway. A new safety barrier is to be constructed within the central reserve. The central reserve will be 2.5m wide and hard-surfaced which, combined with the 1.0m hardstrips on each side, gives an area totalling 4.5m in width.

- Some of the culverts carrying the streams under the A55 carriageway require extending North and South to accommodate the proposed works to the South and the proposed county road and NMU to the North.

- The existing cattle underpasses at Tai'r Meibion farm and Wig farm will be retained and extended and waterproofed. These structures provide a valuable passage underneath the A55(T) for livestock and small agricultural vehicles, as well as wildlife. The cattle creeps will also be available as links in the public footpaths underneath the A55(T).

- The central reservation gaps as well as all existing direct accesses onto the A55(T) over the scheme length will be stopped up, as will the county road junction to Wig Crossing Cottages, thus eliminating all vehicular accesses onto the eastbound carriageway. To accommodate this a new county road and Private Means of Access will be constructed parallel to the eastbound carriageway, to provide alternative access to the fields and properties located north of the A55(T).

- The new county road will commence at the junction with Tal y Bont road near Llain Ffwlbart and continue for approximately 1.6km in an easterly direction parallel with the A55(T) eastbound carriageway and connect with the existing county road to Wig Crossing Cottages. The county road will be constructed to a general width of 3.5m and provide a 1.5m wide path for non-motorised users (NMU).

- A Private Means of Access will provide vehicular access between Wig farm and the new county road. A 2.0m wide NMU route will also be provided along the northern side of the trunk road between the existing county road to Wig Crossing Cottages and the Abergwyngregyn interchange (Junction 13). The NMU route will be widened to 3.5m where it is coincident with the Private Means of Access to Wig Farm. From there, the NMU route narrows to 1.5m where it passes between the A55(T) and Pentre Aber Farm.

- A new direct access for Glyn Farm and the Bryn Meddyg properties onto the A55(T) is proposed, with a link road to the Bryn Meddyg properties. The access has been designed in accordance with TD 42/95 (Geometric Design of Major/Minor Priority Junctions) and incorporates the required merge/diverge tapers whilst ensuring that the required visibility is obtained.

- To the south of the A55(T), the unclassified Roman (Henffordd) Road will be widened over a length of approximately 800m from the access to Tai'r Meibion farm to approximately 180m west of the settlement of Crymlyn. Over this length a 3.5m carriageway width and a 1.5m wide footway will be provided. A new private means of access/access track will be provided to maintain access for Wig and Tai'r Meibion farm land.

- A new footway is proposed between Tan yr Allt cottages and Tan y Lon bus stop to ensure continued pedestrian access to the local bus service. This would have a 1.5m width, except where it crosses the Tan y Lon overpass where it reduces to 900mm due to a restricted area for construction. The new footway would be approximately 850m in length.

- The main structures affected by the Proposed Improvement are two reinforced concrete cattle creeps, each measuring internally 2.7m wide by 2.4m high, which are to be extended. Waterproofing is also to be applied to the outside of the top of the existing cattle creeps and extending 200mm down the sides.

- The northern verge would be 2.5m wide and grassed. The southern verge would also be 2.5m wide but would consist of a 1.7m wide bituminous hard shoulder with a filter drain alongside. The verge width would vary to provide the required visibility splays at the new junction for Glyn Farm and the Bryn Meddyg properties.

3.2. Existing drainage

As part of the improvement works along the A55, the existing drainage arrangements are to be modified in accordance with the proposed carriageway profile.

Currently the surface water run-off from the carriageway is collected via a series of gullies and drains along the verges to the eastbound and westbound carriageways. These drains discharge into a number of culverts carrying the natural watercourses beneath the carriageway. From inspection of the culvert headwalls, these drains range from 450mm to 600mm in diameter.

The existing drainage to the eastbound and westbound carriageway is to be removed and replaced with new. The existing drainage to the westbound carriageway is to be replaced with a series of hydraulic surface water channels with carrier pipes running beneath and filter drain (to capture groundwater form the cutting). From plans provided, it is known that a series of land drains are present adjacent to Tai'r Meibion Farm, extending up the hillside to Roman Road. As part of the proposals these are to remain in place, with the outfalling lengths of pipe reconnected into the proposed carrier pipe system or surface water ditches as shown on drawing number 5055 DR 04/ 5055 DR 05. The gradient of the final length of

pipe will require amending to suit the invert levels of the proposed chambers within the carrier pipe system. This removes the requirement for cross carriageway connections, as is the current arrangement. A series of land drains immediately adjacent to Tai'r Meibion Farm will remain connected to the existing drainage network through a proposed new chamber.

All proposed carrier pipes are designed to receive run-off from the new width of the carriageway and the cut off channel and bund have been modelled to accept run-off from the adjacent greenfield area (including land adjacent to Tai'r Meibion Farm) up to the boundary with Roman Road. From inspection on site, Roman Road has a point drainage infrastructure that intercepts run-off from further up the hillside.

Carriageway crossings

Stream 1

Stream 1 is culverted from a point adjacent to Ty'n Hendre and runs into a series of manholes as shown on drawing 5055DR010. The system picks up drainage from filter drain networks on both sides of the carriageway and then outfalls some 80m North West of the A55.

Stream 2

Stream 2 is culverted through a 1050mm diameter pipe and receives a portion of the surface water for the adjacent junction through gullies located on the junction. The culvert outfalls directly North of the A55.

Stream 3

A 1050mm diameter pipe carries stream 3 under the A55 to 2No. Manholes as shown on drawing 5055DR010 before out-falling at a headwall on the north side of the A55.

Stream 4

Stream 4 is culverted from a point near the roman road to the south of the A55 to a manhole at the South side of the Westbound carriageway From here a 600mm pipe carries the stream to a manhole at the North side of the Eastbound carriageway and subsequently into a stone culvert, carrying the stream North towards the railway.

Stream 5

Stream 5 is culverted under the A55 via a 1050mm diameter pipe, in the central reservation a pipe enters at 9 o'clock and a pipe enters at 3 o'clock. These additional pipes carry surface water from the carriageway and into the culverted stream 5. The culvert outfalls at the North side of the Eastbound carriageway.

Drainage Ditch 5a

Drainage Ditch 5a is carried under the fields to the South of the A55 via a stone culvert which outfalls into a concrete headwall and then into a 350mm diameter concrete pipe. This concrete pipe leads to a manhole to the North side of the Eastbound carriageway and continues into a stone culvert Northwards.

Drainage Ditch 5b

Similarly to Drainage Ditch 5a, Drainage Ditch 5b is carried via a stone culvert under the fields to the south of the A55 and then into a 350mm concrete pipe under the A55. The concrete pipe runs into a manhole at the North side of the Eastbound carriageway and then into a stone culvert Northwards.

Stream 6

Stream 6 is culverted under the A55 via a 800mm diameter pipe, there is an overflow pipe located in the manhole at the central reservations and eventually outfalls back into stream 6 some 28m north of the outlet headwall.

Stream 7

Stream 7 is carried under the A55 via a 900mm diameter pipe to a manhole in the central reservation and then continues to another manhole in the verge at the eastbound carriageway.

As can be seen from the scheme drawings in appendix A, the existing culverts along the route of the scheme require extending in length to accommodate the proposed works. A condition report shows the culverts to be acceptable from a capacity point of view apart from (Stream 5 and 8) and reveals no major structural defects.

This existing drainage summary should be read in conjunction the Road Drainage and Water Environment Report and flood consequence assessment.

3.3. Proposed Carriageway Design

Surface water system

On embankments, the surface water drainage system would comprise channel and gullies routed to carrier drains. Filter drains would be utilised within cuttings.

Kerbed side roads would be drained by gullies or combined kerb and gully systems where applicable.

A combined kerb and gully system along the Northern edge of the new county road will also be implemented.

Drainage networks 3 and 4 would run to an attenuation pond (see 3.4 below), the outflows from which would be restricted, as agreed with NRW, to one third of existing discharge rates prior to discharge to watercourse. At this stage, discharge to ground would be possible, due to soil material being cohesive.

It is likely that a portion of the cutting drainage along the route would be combined in the same pipe system as the highway runoff. The cutting drainage would be captured using filter drains feeding into the highway drain carrier pipes. The filter drains would therefore serve the purpose of cutting drainage, carriageway drainage and formation drainage. However this would be subject to detailed design as practical requirements may require separation where pipe diameters become excessive or where cutting drainage is required to be discharged upstream of the carriageway, to avoid overloading the attenuation pond and flow controls.

To intercept overland flow coming down from the fields to the south of the improvement, a bund and trapezoidal concrete channel configuration will be implemented starting at stream 4 and running east along the South side of the improvement.

Design Standards

The surface water and other elements would be designed in accordance with the following DMRB sections:

HD 33/06 Surface and Sub Surface Drainage for Highways

HA 39/98 Edge of Pavement Details

HD 45/09 Road Drainage and the Water Environment

HA 102/00 Spacing of Road Gullies

HA 103/06 Vegetative Treatment Systems for Highway Runoff

Levels of Service

Typically, the design levels of service for the drains would be to carry a 100% (1 in 1) average annual chance event with no surcharging, and 20% (1 in 5) chance event with surcharging permitted but no surface flooding (HA39 DMRB 4.2). Critical sections such as changes in cross fall and sags would be designed to higher level of service up to no flooding during a 33% (1 in 30) annual chance event.

Carrier drains would be designed to the same criteria, i.e. 100% (1 in 1) annual chance with no surcharge and 20% (1 in 5) annual chance events with surcharge, or a higher level of service at critical sections.

The capacity of drains would be designed in accordance with DMRB HD33/06 and would incorporate a 30% increase in rainfall intensities for the design storm as an allowance for climate change.

3.4. Detention Pond

3.4.1. Attenuation Requirements

The Proposed Improvement drainage design will restrict the peak discharge from the from the pavement drainage to no greater than the pre-development run-off rates. As the extension in carriageway width is predominantly a green field site, the pre-development run off rates would be greenfield rates (see below).

Discharge flows to watercourses would be would be restricted using controls, such as orifice plates or Hydrobrakes; the choice of control would be determined by the flow in each case.

The detention pond would be designed to contain the surface water runoff from the 1% (1 in 100) annual chance event including an allowance for climate change. To allow for potential future climate change, rainfall intensities would be increased by 20% (in accordance with Adapting to Climate Change: Guidance for Flood and Coastal Erosion and Risk Management Authorities in Wales; Welsh Government, 2011). Simulations for a range of storm durations would be undertaken to determine the largest detention volume required for the design event.

Checks would also be undertaken to ensure that the highway run-off for the more frequent events would not exceed the existing Greenfield runoff. The range of flows to be tested is given in Table 3.1.

Storage facilities would be designed generally in accordance with the guidance provided by CIRIA C697 SUDS Manual, and HA 103/06.

3.4.2. Unit Area Runoff Rates

In determining the appropriate Greenfield runoff the following approach has been adopted.

The DMRB indicates that runoff from catchments of less than 50Ha should be assessed using the ADAS 124 method. However, Environment Agency Guidance (June 2012), recommends that FEH methods should now be used in preference for runoff from small catchments.

Therefore, unit area runoff rates for the watercourses along the scheme have been derived using FEH methodology (FEH calculation records are appended to the Flood Consequences Assessment for the Scheme).

Catchment average runoff rates have been derived for the following catchments.

- Stream 1
- Stream 2
- Stream 3
- Stream 4
- Stream 5 (Afon Wig)
- Stream 6
- Stream 7
- Stream 8

The Network details and watercourse details are presented in Table 1.0 and Table 1.1 below.

Table 1.0 Network Details

Network	Catchment Area km^2	Outfall location	Capacity	Time to peak (tp)	Design Discharge (l/s)	Velocity (m/s)
NW01	0.00922	Stream 4	1 in 5	15min	16.4	1.4
NW02	0.00300	Stream 5 (Afon Wig)	1 in 5	15min	39.6	<1
NW03	0.00680	Stream 6	1 in 5	30min	21.4	1.02
NW04	0.01014	Stream 6	1 in 5	30min	105	1.01
NW05	0.00231	Stream 7	1 in 5	15min	24.8	<1
NW05A	0.00190	Stream 7	1 in 5	15min	20	1.2
NW06	0.00764	Stream 8	1 in 5	30min	83.4	2.1
FD01	0.00922	Stream 4	1 in 5	24min	21.6	<1
FD02	0.00300	Stream 5	1 in 5	15min	37.31	1
FD05	0.01200	Stream 7	1 in 5	15min	24.9	1
FD05A	0.00190	Stream 7	1 in 5	15min	19.7	1.2

Table 1.1 Watercourse details

Culvert	Catchment Area (km^2)	100yr CC Capacity	Length	Diameter	Upstream invert level (m AOD)	Downstream invert level (m AOD)	Flow from 100+CCyr rainfall event (m^3/s)	Time to Peak (h)	Velocity (m/s)
Stream 1	1.63	Yes	300m	1050mm	50.1	24.241	1.97	2.1	7.82
Stream 2	0.4	Yes	47m	1200mm	27.091	26.340	1.08	1.9	5.38
Stream 3	0.4	Yes	56m	1200mm	23.793	20.746	1.25	2	5.3
Stream 4	0.70	Yes	52m	900mm	24.612	21.088	2.7	2.4	5.13
Stream 5	2.49	No	33m	900mm	24.8	24.268	8.7	2.3	4.26
Stream 6	0.96	Yes	26m	900mm	27.3	26.771	3.6	1.9	1.96
Stream 7	0.67	Yes	25m	925mm	29.62	27.645	2.54	1.9	2.58
Stream 8	0.48	no	25m	300mm	27.9	26.57	1.8	1.8	3.8

3.4.3. Pollution Control Requirements

The main sources of pollution in carriageway runoff are hydrocarbons, suspended particle matter (with associated heavy metals), and dissolved solids (containing zinc and copper).

The Environment Agency's Pollution Prevention Guidance note 3 (PPG3, 2006) require that consideration would need to be given to protecting the environment from pollution by oils and hydrocarbons. This can be achieved by either oil interceptors or the use of sustainable drainage systems (SUDS). SUDS include ponds, wetlands or swales.

The Water Quality chapter of the Environmental Statement (ES) covers pollution control requirements more fully. An assessment was carried out under the terms of documentation. Road and Drainage Environment (chapter 5.10) section of the ES determined the respective treatment requirements for water quality and indicates that no mitigation is required; however the installation of a detention pond, grass verges and filter drains will have a significant improvement in pollution control off the carriageway.

The outfall from the storage facility would be equipped with a system to retain hydrocarbons within the permanently wet area, (similar to the mechanisms shown on Figure 2.5, HA 103/06). These systems operate on the same principles as full retention oil separators. This approach is subject to agreement with NRW.

Transported sediments would be removed by sedimentation within the pond. Dissolved solids can be removed through plant metabolism in vegetative treatment systems or the use of vortex separators, which would be provided by dedicated planted areas. Hydrocarbons would be removed partially in wet ponds and partially by natural breakdown in the planted areas. They would also be partially removed in any filter drains.

If any attenuation solutions other than wet ponds need to be utilised, consideration would need to be given to how the required pollution control requirements could be achieved.

3.4.4. Storage Options

Hybrid ponds

The use of carefully designed open ponds using a combination of wet area and normally dry detention basin would satisfy both the pollution control requirements and the attenuation requirements discussed above. These have the advantages over enclosed storage in that they provide easier access for construction

and maintenance purposes and eliminate confined spaces. It is envisaged that a hybrid pond would be provided at one location in the scheme.

This would typically comprise an inlet structure, fore bay, vegetative treatment for pollution control, detention storage, lined wet area, and outlet control structure. The inlet structure would contain a high level bypass with piped connection to the outlet structure. The outlet structure would be equipped with gabion baffles to prevent hydrocarbons, flow controls and isolation penstocks. The flow controls would be orifice plates where possible (minimum diameter 75mm), or hydrobrakes for smaller flows. Isolation penstocks have been proposed only at the outlet structures (rather than both inlet and outlet) as this would prevent the contents from discharging to watercourse in the event of a spillage when the detention storage is in operation (isolation penstocks on the upstream side would only isolate flows into but not away from the tank).

It should be noted that gabion or other retaining walls may be required to provide access or where space is limited.

Current proposals are that only wet areas would be lined. The remainder of the storage area would be unlined to allow infiltration into the underlying sub soils. Further assessment would be undertaken as part of the detailed design to ensure that such infiltration would not contribute to areas of instability or areas at risk from landslip.

Based on ground investigations reported in the Geotechnical Report (Volume 1, 5.5, of the Environment Statement), full infiltration drainage is not considered a viable option for the scheme for the following reasons.

- Generally along the route of the scheme, impermeable rock lies approximately 1m below ground level, and
- Where more permeable gravels or made ground underlies the scheme, these correspond with areas of instability and areas at risk of land slip.

Oversized pipes

For some smaller localised areas, consideration is given to utilising open channels if required.

Oversized pipes are also considered for storage in specific situations, in particular where insufficient open area is available beside the road to accommodate ponds. This would apply to small areas which may not easily accommodate storage ponds.

3.4.5. Preferred Solution

Hybrid ponds are the preferred solution as they achieve all the project objectives, i.e. pollution control and attenuation. However, due to land constraints oversized pipes are also used.

Table 1.2 below shows a list of the storage facilities and approximate volumes of storage required. The volume would be confirmed at detailed design stage.

Table 1.2 Storage solutions

Network reference	Receiving watercourse	Chainage (m)	Total impermeable area (Ha)	Storage solution	Approximate volume (m^3)
YGCNW01	Stream 4	90 - 350	0.922	Oversised pipes	63.162
YGCNW02	Stream 5 (Afon Wig)	400 - 670	0.300	Oversized pipes	28.131
YGCNW03	Stream 6	740 - 1010	0.680	Detention pond	113.230
YGCNW04	Stream 6	1010 - 1440	1.054	Detention Pond	154.239
YGCNW05	Stream 7	1570 - 1744	0.231	Oversized pipes	19.179
YGCNW05A	Stream 7	1440 - 1570	0.190	Oversized pipes	12.339
YGCNW06	Stream 8	1570 - 2040	0.764	Oversized pipes	75.103
YGCFD01	Stream 4	90 – 350	0.922	Oversized pipes	67.944
YGCFD02	Stream 5 (Afon Wig)	400 – 670	0.300	Oversized pipes	27.510
YGCFD05	Stream 7	1570 – 1744	0.220	Oversized pipes	16.179
YGCFD05A	Stream 7	1440 - 1570	0.190	Oversized pipes	13.748
				Total	590.764m^3

3.5. Proposed Off Site Drainage

In this context the term off site drainage covers all drainage at fence lines, cuttings, embankments, toe drains and cut off ditches. The watercourses and culverts crossing the line of the highway are outside the scope of this report, and are covered by the Flood Consequences Assessment Report.

Additional drainage mitigation measures
Following concerns raised by NRW and the residents of Wig Crossing Cottages in relation to the potential build- up of surface water behind the proposed mitigation wall, there will be a commitment to ensure that the cottages are not at increased risk of surface water runoff from the surrounding area. There will be an additional outfall from the railway embankment of a minimum size of 300mm diameter. A minimum 300mm diameter pipe will also be incorporated within the surface water drainage to the south of Wig Crossing Cottages draining into the Afon Wig (Stream 5) from the Wig Crossing Cottages access track. The increased outfalls and drainage of surface water will ensure that Wig Crossing Cottages will not be at increased risk of surface water pooling behind the proposed mitigation wall. The full calculation sheet can be found in the Flood Consequence Assessment within Technical Appendix D of Volume 2.

3.5.1. Fence line and cutting drainage

Fence line drainage would be provided to intercept overland flow from reaching the highway and to prevent flows from flooding the highway cuttings and embankments from reaching adjacent property.

Standards

It would be designed in accordance with the requirements of:

HA 106/04 Drainage of Runoff from Natural Catchments

HA 119/06 Grassed Surface Water Channels for Highway Runoff

Levels of Service

The fence line and cutting drainage would be designed to accommodate the 1.33% (1 in 75) annual chance flood event (although land drainage culverts are designed to the 1% (1 in 100) annual chance flood event including climate change allowance). It should be noted that assessments based on ADAS for smaller catchments <0.4 km^2, or IH124 for larger catchments as described in the DMRB is not now in line with NRW current industry best practice for assessment of runoff from small catchments.

This drainage would generally take the form of lined trapezoidal pre cast concrete channels with a bund; these would be directed to the nearest watercourse. Flow down the faces of cuttings would be captured by the highway drainage system.

Flow down earthwork embankments would be intercepted by V ditch toe drains and filter drains connecting with the nearest watercourse. If possible these would be designed as small swales in flatter areas, providing an element of SUDS with a grassed verged.

The carriageway drainage is designed for short term storms and is attenuated prior to discharge. The fence line drainage is designed for longer duration storms, and flows directly to outfall / watercourse without the need for attenuation.

3.6. Trash Screens

The current Trash screen configurations at the inlet to culverts under the A55(T) at streams 5, 6 and 7 are substandard and the suitability of these screens needs to be reviewed.

Following guidance from 'Trash and Security Screen Guide 2009, EA' the area of screen required to collect debris and be cleared effectively are 14.823m^2, 11.156m^2 and 7.438m^2 respectively.
Stream 5a and 5b also require new trash screens and both require a screen area of 7.438m^2.

To accommodate these trash screens, around 2.5m of land will be needed either side of the centre of each culvert the length of each structure will vary according to the requirements of each culvert.

4. Consultation

4.1. Natural Resources Wales

Comments received by NRW;

The main river map for the area has not been amended since 2008, however we no longer are the consenting body for the culverting of ordinary watercourses (under Section 23 of the Land Drainage Act 1991). Since the implementation of the Floods and Water Management Act in 2012, the consenting bodies for S23 consents are that of the Lead Local Flood Authorities (Gwynedd Councils' Flood and Coastal Risk Management Unit in this instance).

The Afon Wig @ NGR SH6342971948 is classified as that of a main river and as such consent would be required (under Section 109 of the Water Resources Act) from the Natural Resources Wales. All other culverting of watercourses associated with the scheme will be under S.23 of the LDA. Culverting lengths should be kept as short as possible and only for access purposes. For your information, the Ty'n Hendra and Afon Wig are main rivers from the main line railway downstream to sea.

In the first instance we would request that any discharge rates maintain existing green field run off rates. It is assumed/accepted that existing drainage from the A55 is uncontrolled. It may be acceptable to provide 'betterment' in terms of discharge rates to reduce the flows by say 1/3rd of existing rates but we appreciate that this may have a fairly large land take footprint. Can't see an objection provided that the run off rates are reduced and that culverts have been sized accordingly and are kept to as short as possible to allow for access crossings.

5. Summary

Summary

A kerb and gulley system is proposed to drain the highway along sections of embankment together with filter drains proposed in cuttings. These would capture carriageway runoff and a portion of the cutting drainage along with groundwater.

Attenuation, using storage pond systems and flow controls is proposed to restrict the proposed discharge to no more than the pre-development Greenfield run-off and reduction to a third of the current discharge rates.

Pollution control measures would be provided by catchpits and settlement areas in the fore bays of the attenuation pond. There would also be a degree of vegetative treatment in the pond. Shut-off valves would be provided at pond outlets.

Access for future maintenance would be provided to all attenuation, pollution control and outfall facilities as appropriate.

Micro drainage models have been produced for the carriageway drainage catchments.

Fence line drains would predominantly be trapezoidal pre cast concrete channels out-falling into the nearest watercourse.

KEY

- Existing Water Course (For further details refer to the drainage section of the Appropriate Assessment)
- Existing culvert alignment
- Proposed extension to existing culvert
- Proposed surface water carrier drain (The information given should be read in conjunction with the MicroDrainage system reports) (Arrow indicates direction of flow)
- Proposed surface filter drain (Arrow indicates direction of flow)
- New culvert
- Existing surface water chamber
- Proposed surface water chamber
- Proposed surface water chamber with flow control device (Refer to the Microdrainage system reports for discharge restriction)
- Proposed surface water grassed channel outlet chamber
- Proposed trapped road gully and 150mm diameter connection
- Proposed headwall
- Dense Vegetation
- Proposed Channel Widening
- Location of existing erosion
- Existing gabion baskets
- Banks to be battered back

NOTES

1. For details of grassed surface water channels refer to the Design Criteria Report
2. Overgrown vegetation around channel boundary obscuring view of channel sides. Clearance of vegetation recommended.
3. Stream 1 has undercut existing gabion baskets.
4. The provision of geotextile is recommended for bank protection.
5. Possible provision of geotextile within woodland reach subject to further investigation.
6. Weir structures to be placed between 5-15 metres apart along section, Show on plan.
7. Crump weir design is based on BS3680-b4.
8. All dimensions are in millimetres.

Install brush matress

Woodland emcompasing stream unable to view channel unsure of erosion extent

Underscouring of gabions

Existing gabion baskets

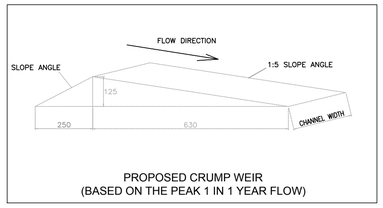
Banks to be battered back to approx 60° to horizontal to accommodate geotextile

Land required for track re-alignment

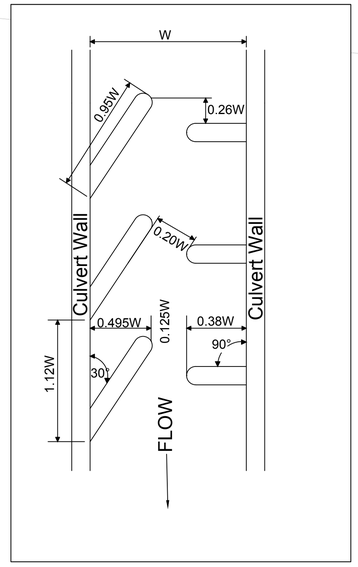
Area of Energy dissipation

Direction of flow

Section containing proposed Crump Weirs between 5 and 15m apart. See detail



PROPOSED CRUMP WEIR
(BASED ON THE PEAK 1 IN 1 YEAR FLOW)



Proposed offset baffle pattern to aid energy dissipation on all required outfalls

Chamber ref. N1.1
CL 26.856
IL 25.656

Pipe ref. N1.1.001
Diameter : 150mm
Gradient : 1/58.5
Length : 51.000m

CR NW01

Pipe ref. N1.1.000
Diameter : 150mm
Gradient : 1/58.5
Length : 36.600m

Chamber ref. N1.2
CL 26.604
IL 25.030

Controlled discharge of 7.5 l/s into culvert

Controlled discharge of 11.5 l/s into culvert

STREAM 1

Proposed 1050mm diameter culvert

Chamber ref. N2.4
CL 26.000
IL 23.623

Chamber ref. N2.3
CL 25.713
IL 24.106

Pipe ref. N2.1.003
Diameter : 225mm
Gradient : 1/99.3
Length : 44.000m

Pipe ref. N2.1.002
Diameter : 225mm
Gradient : 1/99.3
Length : 48.000m

CR NW02

Pipe ref. N2.1.001
Diameter : 225mm
Gradient : 1/99.3
Length : 28.000m

Chamber ref. N2.2
CL 25.858
IL 24.388

Pipe ref. N2.1.000
Diameter : 225mm
Gradient : 1/99.2
Length : 26.000m

Chamber ref. N2.1
CL 26.000
IL 24.650

RHIF NO.	NEWIDIADAU MODIFICATIONS	GAN DRAWN	DYDDIAD DATE	GWIRIWYD CHECKED

YGC FRLEA

CYNGOR GWYNEDD COUNCIL

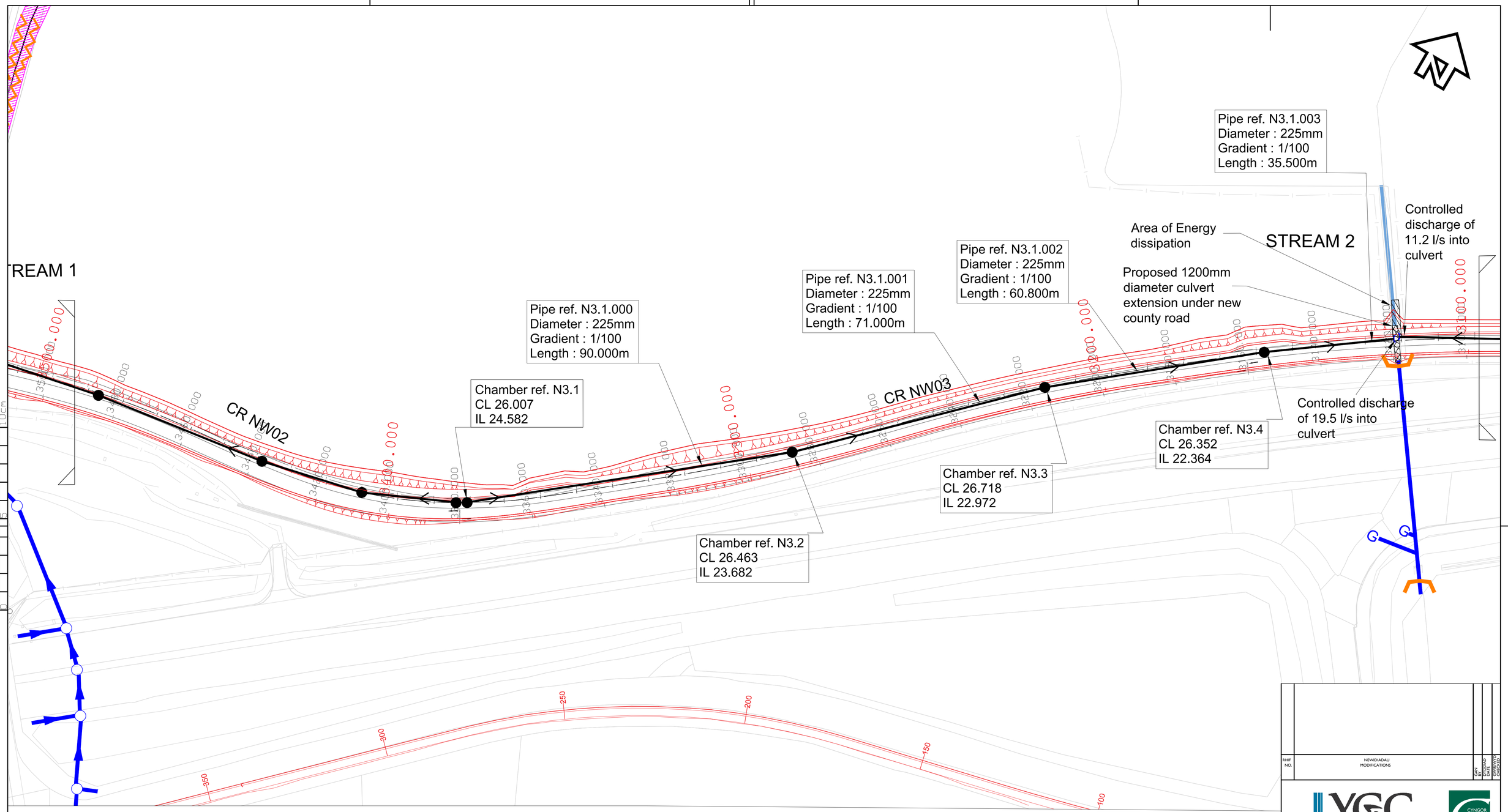
CYNLLUN / SCHEME :
A55 Tai'r Meibion to Abergwyngregyn Junction 12 to 13 Improvements

TEITL LLUNIAD / DRAWING TITLE :
Drainage Drawing 1

DARLUNWYD GAN : DRAWN BY :	EH	DYDDIAD DARLUNWYD : DATE DRAWN :	24/09/2015
GWIRIWYD GAN : CHECKED BY :	RW	DYDDIAD GWIRIWYD : DATE CHECKED :	25/09/2015
Taflen Sheet	1 o 9	GRADDFEYDD : SCALES :	1:500@A1

Rhif Lluniad Drawing No. 5055 DR 01

CYWI REV A



KEY

- Existing Water Course (For further details refer to the drainage section of the Appropriate Assessment)
- Existing culvert alignment
- Proposed extension to existing culvert
- Proposed surface water carrier drain (The information given should be read in conjunction with the MicroDrainage system reports) (Arrow indicates direction of flow)
- Proposed surface filter drain (Arrow indicates direction of flow)
- Existing surface water chamber
- Proposed surface water chamber
- Proposed Catchpit
- Proposed surface water chamber with flow control device
- Proposed surface water grassed channel outlet chamber
- Proposed trapped road gully and 150mm diameter connection
- Proposed headwall

NOTES

1 Surface water channel outlet locations shown as preliminary.

2 For details of the network shown refer to the Design Criteria Report

RHIF NO.	NIEWIDIADAU MODIFICATIONS	GAN BY	DYDDIAD DATE	CYMERADWYO CHECKED

YGC AREA FRAM

CYNGOR GWYNEDD COUNCIL

CYNLLUN / SCHEME :

A55 Tai'r Meibion to Abergwyngregyn Junction 12 to 13 Improvements

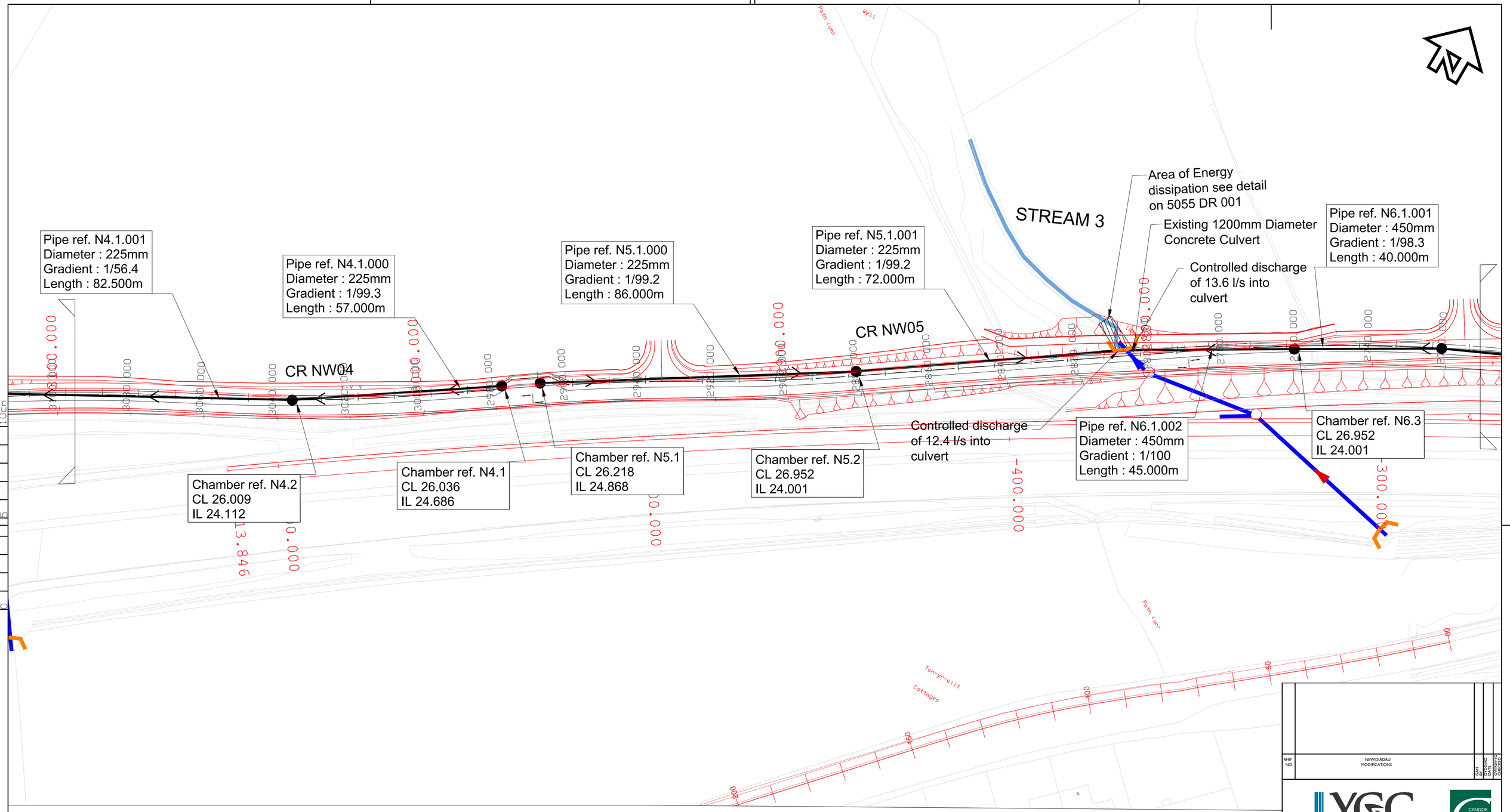
TEITL LLUNIAD / DRAWING TITLE :

Drainage Drawing 2

DARLUNWYD GAN : DRAWN BY :	EH	DYDDIAD DARLUNWYD : DATE DRAWN :	24/09/2015
GWIRIWYD GAN : CHECKED BY :	RW	DYDDIAD GWIRIWYD : DATE CHECKED :	25/09/2015
Taflen Sheet	2 o of 9	GRADDFEYDD : SCALES :	1:500@A1

Rhif Lluniad Drawing No. 5055 DR 02

CYWI REV A



KEY

- Existing Water Course (For further details refer to the drainage section of the Appropriate Assessment)
- Existing culvert alignment
- Proposed extension to existing culvert
- Proposed surface water carrier drain (The information given should be read in conjunction with the MicroDrainage system reports) (Arrow indicates direction of flow)
- Proposed surface filter drain (Arrow indicates direction of flow)
- Existing surface water chamber
- Proposed surface water chamber
- Proposed Catchpit
- Proposed surface water chamber with flow control device
- Proposed surface water grassed channel outlet chamber
- Proposed trapped road gully and 150mm diameter connection
- Proposed headwall

NOTES

1 Surface water channel outlet locations shown as preliminary.

2 For details of the network shown refer to the Design Criteria Report

RHIF NO.	NEWIDIADAU MODIFICATIONS	GAN DRAWN	DYDDIAD DATE	GWIRIWYD CHECKED

CYNLLUN / SCHEME :

A55 Tai'r Meibion to Abergwyngregyn Junction 12 to 13 Improvements

TEITL LLUNIAD / DRAWING TITLE :

Drainage Drawing 3

DARLUNWYD GAN : DRAWN BY :	EH	DYDDIAD DARLUNWYD : DATE DRAWN :	24/09/2015
GWIRIWYD GAN : CHECKED BY :	RW	DYDDIAD GWIRIWYD : DATE CHECKED :	25/09/2015
Taflen Sheet	3 o 9 of	GRADDFEYDD : SCALES :	1:500@A1

Rhif Lluniad Drawing No. 5055 DR 03

CYWI REV A

Pipe ref. N6.1.000
Diameter : 400mm
Gradient : 1/27.4
Length : 80.000m

Pipe ref. N7.1.000
Diameter : 400mm
Gradient : 1/100
Length : 43.000m

Pipe ref. N7.1.001
Diameter : 400mm
Gradient : 1/100
Length : 45.000m

Pipe ref. N7.1.002
Diameter : 400mm
Gradient : 1/27.9
Length : 79.000m

Pipe ref. N7.1.003
Diameter : 400mm
Gradient : 1/22.2
Length : 48.000m

Pipe ref. N7.1.004
Diameter : 400mm
Gradient : 1/100
Length : 68.000m

CR NW06

CR NW07

STREAM 4

Controlled discharge of 22.7 l/s into culvert

Chamber ref. N6.2
CL 24.758
IL 23.963

Chamber ref. N6.1
CL 28.261
IL 26.911

Chamber ref. N7.1
CL 28.372
IL 26.947

Chamber ref. N7.2
CL 29.832
IL 26.517

Chamber ref. N7.3
CL 29.581
IL 26.067

Chamber ref. N7.4
CL 24.836
IL 23.236

Chamber ref. N7.5
CL 22.464
IL 21.069

Existing Culvert

New chamber (Reference E)
to accommodate
land and highway drainage
due to extension of highway
width

KEY

- Existing Water Course (For further details refer to the drainage section of the Appropriate Assessment)
- Existing culvert alignment
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- Proposed surface water carrier drain (The information given should be read in conjunction with the MicroDrainage system reports) (Arrow indicates direction of flow)
- Proposed surface filter drain (Arrow indicates direction of flow)
- Existing surface water chamber
- Proposed surface water chamber
- Proposed Catchpit
- Proposed surface water chamber with flow control device
- Proposed surface water grassed channel outlet chamber
- Proposed trapped road gully and 150mm diameter connection
- Proposed headwall

NOTES

1 Surface water channel outlet locations shown as preliminary.

2 For details of the network shown refer to the Design Criteria Report

RHIF NO.	NEWIDIADAU MODIFICATIONS	GAN DRAWN	DYDDIAD DATE	GWIRIWYD CHECKED

YGC

CYNGOR GWYNEDD COUNCIL

CYNLLUN / SCHEME :

A55 Tai'r Meibion to Abergwyngregyn
Junction 12 to 13 Improvements

TEITL LLUNIAD / DRAWING TITLE :

Drainage Drawing 4

DARLUNWYD GAN : DRAWN BY :	EH	DYDDIAD DARLUNWYD : DATE DRAWN :	24/09/2015
GWIRIWYD GAN : CHECKED BY :	RW	DYDDIAD GWIRIWYD : DATE CHECKED :	25/09/2015
Taflen Sheet	4 o of 9	GRADDFEYDD : SCALES :	1:500@A1

Rhif Lluniad
Drawing No. 5055 DR 04

CYWI REV

Controlled discharge of 21.61 l/s into culvert

Chamber ref. N8.1
CL 28.000
IL 26.800

Pipe ref. N8.1.000
Diameter : 450mm
Gradient : 1/99.3
Length : 90.000m

Filter Drain Ref: FD01

Pipe ref. N8.1.001
Diameter : 450mm
Gradient : 1/99.3
Length : 60.000m

Chamber ref. N8.2
CL 27.000
IL 25.894

CR NW08

Pipe ref. N8.1.002
Diameter : 450mm
Gradient : 1/99.3
Length : 61.000m

Chamber ref. N8.3
CL 26.000
IL 25.290

Controlled discharge of 16.7 l/s into culvert

Area of Energy dissipation

STREAM 5 (AFON WIG)

Controlled discharge of 37.3 l/s into culvert

New 3.6m² box culvert to replace existing

SUMMIT

VALLEY

Filter Drain Ref: FD01

Drainage Network Ref: NW01

Chamber ref. N1.4
CL 26.097
IL 24.195

Pipe ref. N1.1.003
Diameter : 700mm
Gradient : 1/46.4
Length : 29.90m

Controlled discharge of 16.9 l/s into culvert

Pipe ref. N1.1.002
Diameter : 700mm
Gradient : 1/909.1
Length : 100.00m

Chamber ref. N1.3
CL 26.620
IL 24.225

Pipe ref. N1.1.001
Diameter : 600mm
Gradient : 1/913.2
Length : 48.40m

Pipe ref. N1.1.000
Diameter : 600mm
Gradient : 1/910.8
Length : 84.70m

Chamber ref. N1.1
CL 26.651
IL 24.451

Chamber ref. N1.2
CL 26.458
IL 24.308

Chamber ref. N2.4
CL 27.074
IL 25.197

New headwall and screen arrangement

Controlled discharge of 28.3 l/s into culvert

Pipe ref. N2.1.002
Diameter : 300mm
Gradient : 1/238
Length : 63.3m

Pipe ref. N2.1.003
Diameter : 300mm
Gradient : 1/238
Length : 3.2m

KEY

- Existing Water Course (For further details refer to the drainage section of the Appropriate Assessment)
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- Proposed surface filter drain (Arrow indicates direction of flow)
- Existing surface water chamber
- Proposed surface water chamber
- Proposed Catchpit
- Proposed surface water chamber with flow control device
- Proposed trapped road gully and 150mm diameter connection
- Proposed headwall
- Area required for trash screen

NOTES

1 Surface water channel outlet locations shown as preliminary.

2 For details of the network shown refer to the Design Criteria Report

RHIF NO.	NEWIDIADAU MODIFICATIONS	GAN	DYDDIAD DATE	GWIRIWYD CHECKED

YGC FRERM

CYNGOR GWYNEDD COUNCIL

CYNLLUN / SCHEME :

A55 Tai'r Meibion to Abergwyngregyn Junction 12 to 13 Improvements

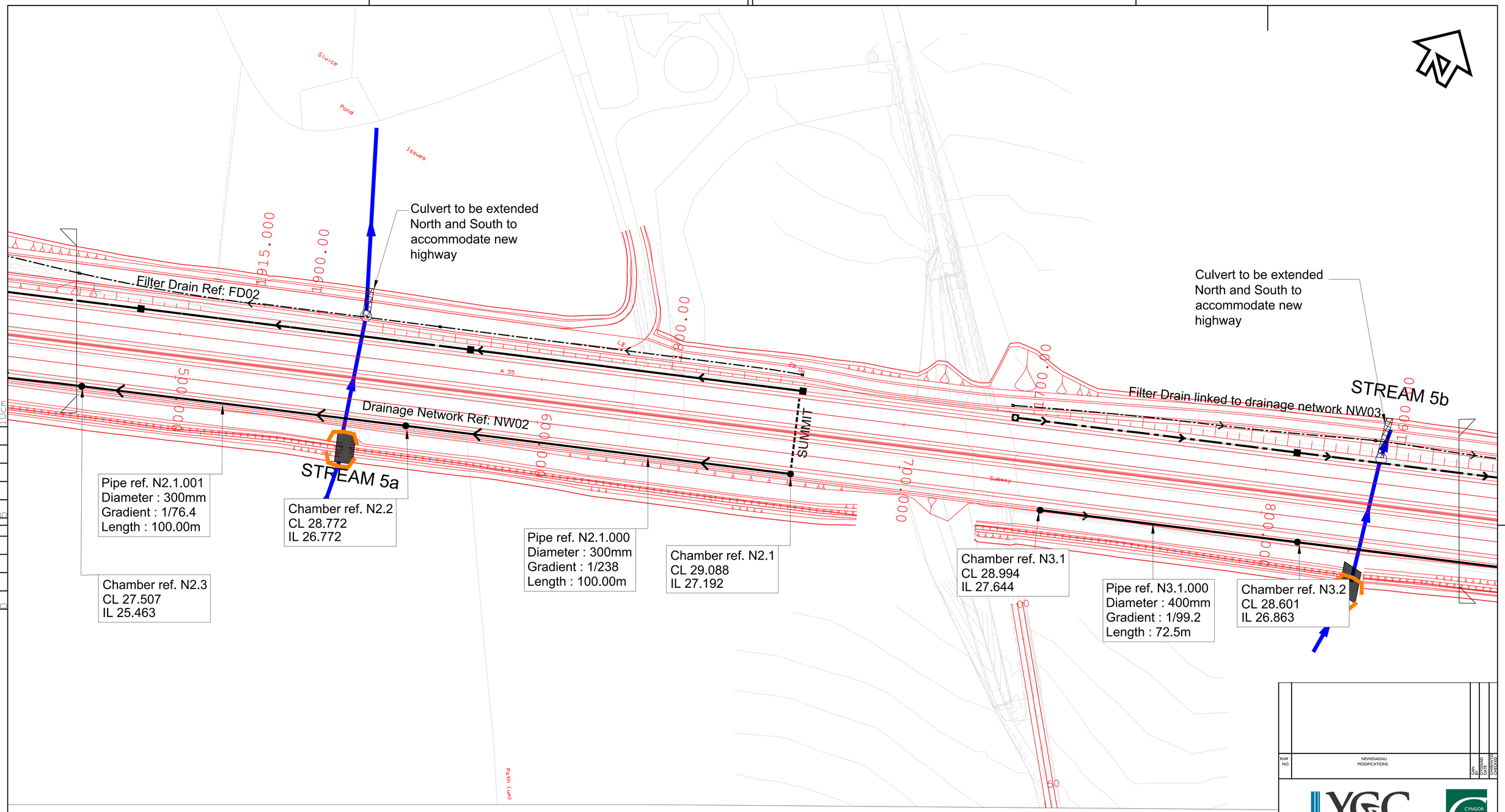
TEITL LLUNIAD / DRAWING TITLE :

Drainage Drawing 5

DARLUNWYD GAN : DRAWN BY :	EH	DYDDIAD DARLUNWYD : DATE DRAWN :	24/09/2015
GWIRIWYD GAN : CHECKED BY :	RW	DYDDIAD GWIRIWYD : DATE CHECKED :	25/09/2015
Taflen Sheet	5 of 9	GRADDFEYDD : SCALES :	1:500@A1

Rhif Lluniad Drawing No. 5055 DR 05

CYWI REV A



KEY

- Existing Water Course (For further details refer to the drainage section of the Appropriate Assessment)
- Existing culvert alignment
- Proposed extension to existing culvert
- Proposed surface water carrier drain (The information given should be read in conjunction with the MicroDrainage system reports) (Arrow indicates direction of flow)
- Proposed surface filter drain (Arrow indicates direction of flow)
- Existing surface water chamber
- Proposed surface water chamber
- Proposed Catchpit
- Proposed surface water chamber with flow control device
- Proposed trapped road gully and 150mm diameter connection
- Proposed headwall
- Area required for trash screen

NOTES

1 Surface water channel outlet locations shown as preliminary.

2 For details of the network shown refer to the Design Criteria Report.

3 The filter drains to the Private Means of Access and to the Cycleway are shown indicative only.

4 Highway drainage not proposed to discharge into culvert 5a and 5b.

RHIF NO.	NEWIDIADAU MODIFICATIONS	GAN BY	DYDDIAD DATE	CYMERADWYO CHECKED

YGC FCERM

CYNGOR GWYNEDD COUNCIL

CYNLLUN / SCHEME :

A55 Tai'r Meibion to Abergwyngregyn Junction 12 to 13 Improvements

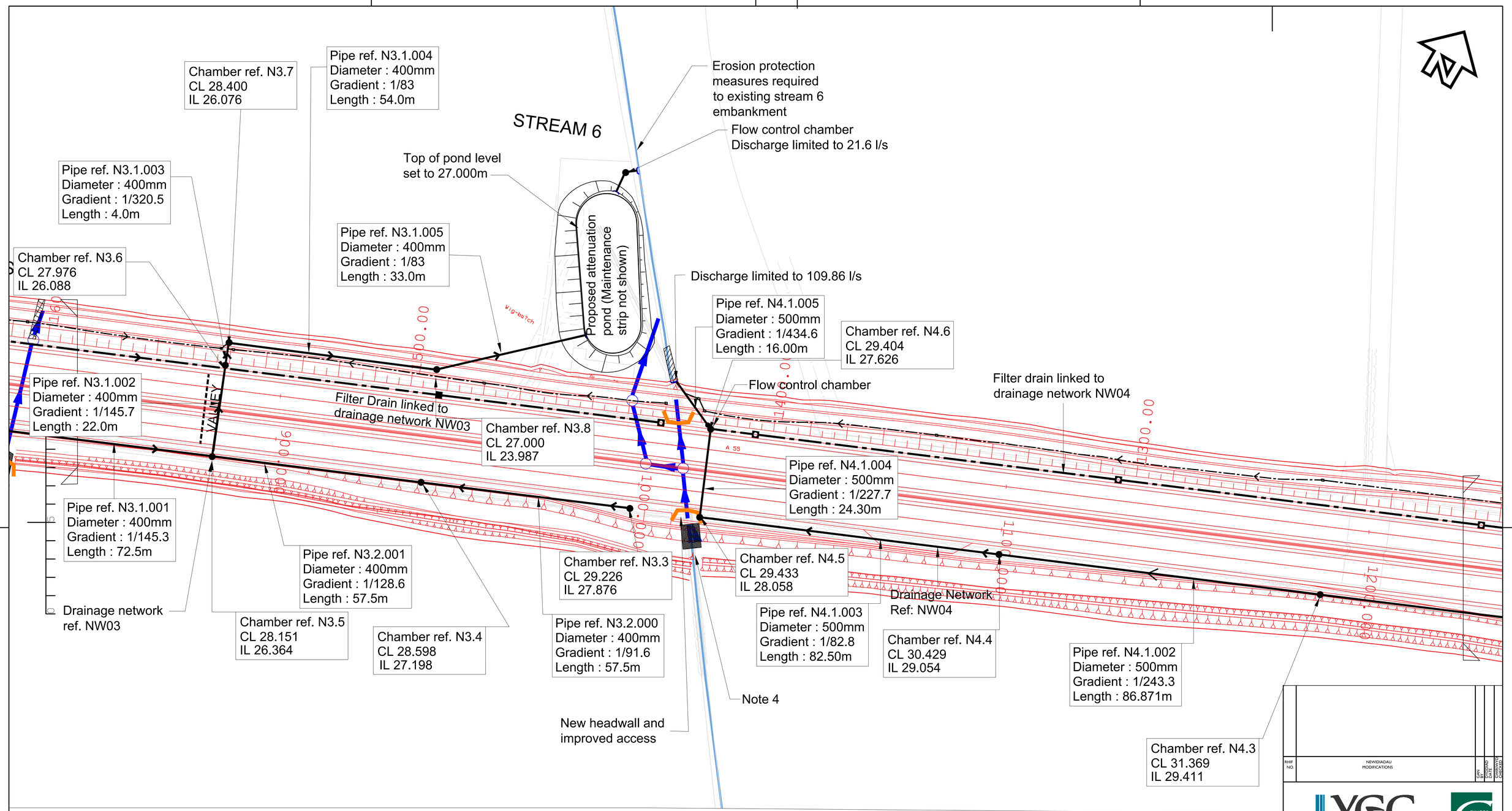
TEITL LLUNIAD / DRAWING TITLE :

Drainage Drawing 6

DARLUNWYD GAN : DRAWN BY :	EH	DYDDIAD DARLUNWYD : DATE DRAWN :	24/09/2015
GWIRIWYD GAN : CHECKED BY :	RW	DYDDIAD GWIRIWYD : DATE CHECKED :	25/09/2015
Taflen Sheet	6 of 9	GRADDFEYDD : SCALES :	1:500@A1

Rhif Lluniad Drawing No. 5055 DR 06

CYWI REV A



KEY

- Existing Water Course (For further details refer to the drainage section of the Appropriate Assessment)
- Existing culvert alignment
- Proposed extension to existing culvert
- Proposed surface water carrier drain (The information given should be read in conjunction with the MicroDrainage system reports) (Arrow indicates direction of flow)
- Proposed surface filter drain (Arrow indicates direction of flow)
- Existing surface water chamber
- Proposed surface water chamber
- Proposed Catchpit
- Proposed surface water chamber with flow control device
- Proposed trapped road gully and 150mm diameter connection
- Proposed headwall
- Area required for trash screen

NOTES

1 Surface water channel outlet locations shown as preliminary.

2 For details of the network shown refer to the Design Criteria Report.

3 The filter drains to the Private Means of Access and to the Cycleway are shown indicative only.

4 Watercourse to be regraded for removal of stepped revetment to improve fish passage.

RHIF NO.	NEWIDIADAU MODIFICATIONS	GAN BY	DYDDIAD DATED	GWIRIWYD CHECKED

YGC RRLEA FCERM

CYNGOR GWYNEDD COUNCIL

CYNLLUN / SCHEME :

A55 Tai'r Meibion to Abergwyngregyn Junction 12 to 13 Improvements

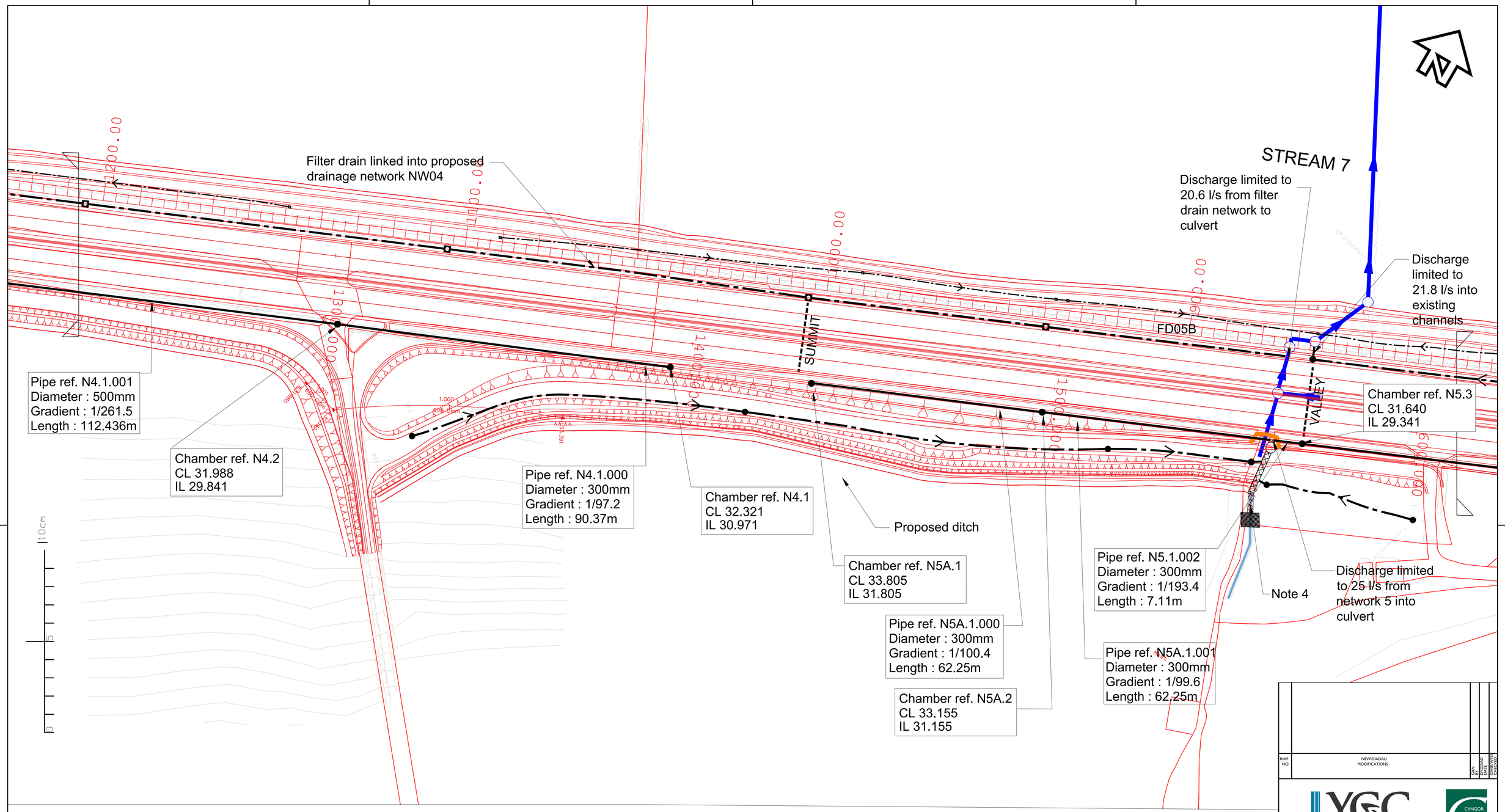
TEITL LLUNIAD / DRAWING TITLE :

Drainage Drawing 7

DARLUNWYD GAN : DRAWN BY :	EH	DYDDIAD DARLUNWYD : DATE DRAWN :	24/09/2015
GWIRIWYD GAN : CHECKED BY :	RW	DYDDIAD GWIRIWYD : DATE CHECKED :	25/09/2015
Taflen Sheet	7 of 9	GRADDFEYDD : SCALES :	1:500@A1

Rhif Lluniad Drawing No. 5055 DR 07

CYWI REV A



KEY

- Existing Water Course (For further details refer to the drainage section of the Appropriate Assessment)
- Existing culvert alignment
- Proposed extension to existing culvert
- Proposed surface water carrier drain (The information given should be read in conjunction with the MicroDrainage system reports) (Arrow indicates direction of flow)
- Proposed surface filter drain (Arrow indicates direction of flow)
- Existing surface water chamber
- Proposed surface water chamber
- Proposed Catchpit
- Proposed surface water chamber with flow control device
- Proposed trapped road gully and 150mm diameter connection
- Proposed headwall
- Area required for trash screen

NOTES

1 Surface water channel outlet locations shown as preliminary.

2 For details of the network shown refer to the Design Criteria Report.

3 The filter drains to the Private Means of Access and to the Cycleway are shown indicative only.

4 Requirements of watercourse re-grading including construction of cascade arrangement and removal of stepped revetment to achieve culvert invert level.

RHIF NO.	NEWIDIADAU MODIFICATIONS	GAN BY	DYDDIAD DATE	GWIRIWYD CHECKED

YGC FCERM

CYNGOR GWYNEDD COUNCIL

CYNLLUN / SCHEME :

A55 Tai'r Meibion to Abergwyngregyn Junction 12 to 13 Improvements

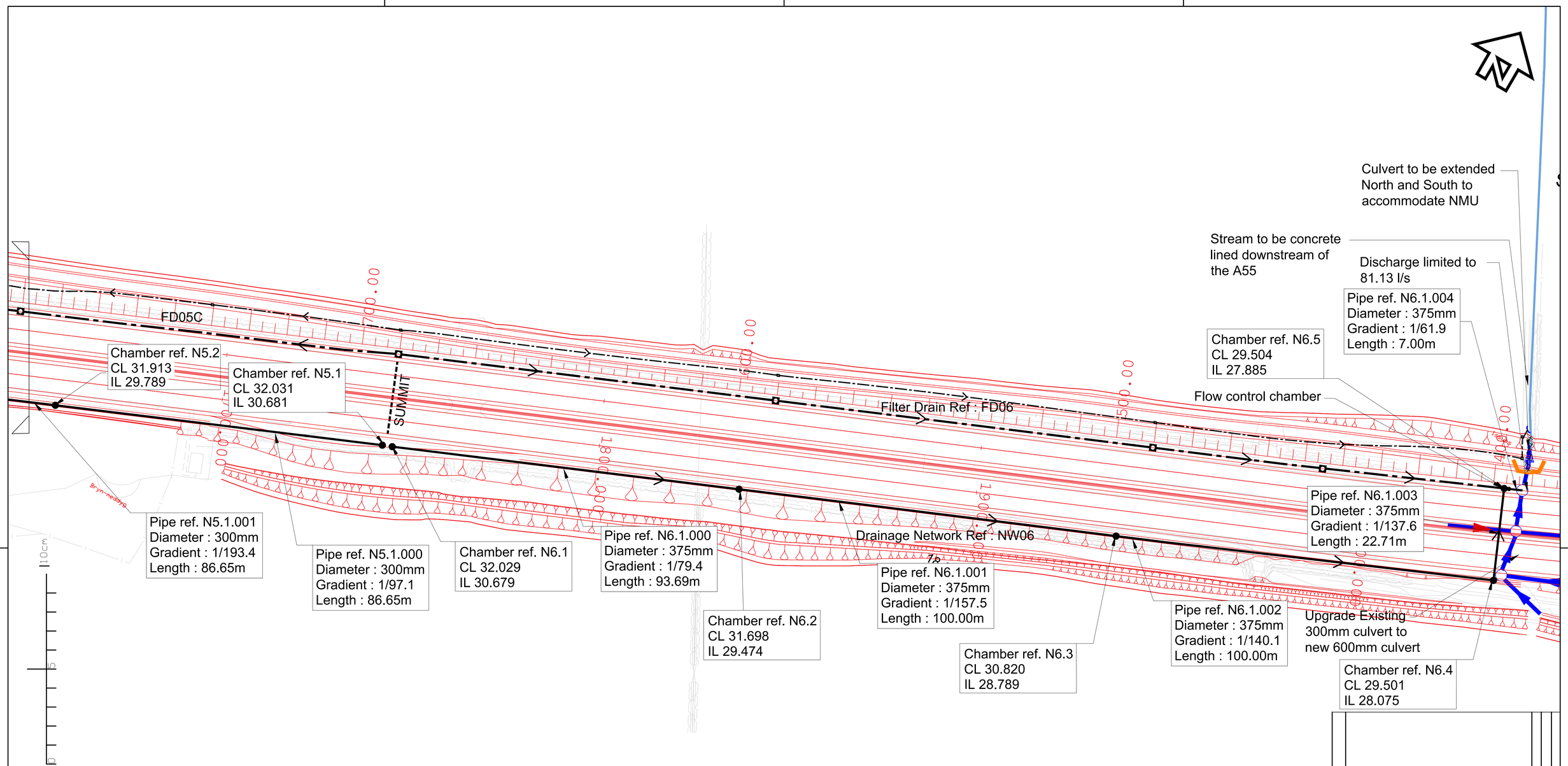
TEITL LLUNIAD / DRAWING TITLE :

Drainage Drawing 8

DARLUNWYD GAN : DRAWN BY :	EH	DYDDIAD DARLUNWYD : DATE DRAWN :	24/09/2015
GWIRIWYD GAN : CHECKED BY :	RW	DYDDIAD GWIRIWYD : DATE CHECKED :	25/09/2015
Taflen Sheet	8 o 9 of	GRADDFEYDD : SCALES :	1:500@A1

Rhif Lluniad Drawing No. 5055 DR 08

CYWI REV A



KEY

- Existing Water Course (For further details refer to the drainage section of the Appropriate Assessment)
- Existing culvert alignment
- Proposed extension to existing culvert
- Proposed surface water carrier drain (The information given should be read in conjunction with the MicroDrainage system reports) (Arrow indicates direction of flow)
- Proposed surface filter drain (Arrow indicates direction of flow)
- Existing surface water chamber
- Proposed surface water chamber
- Proposed Catchpit
- Proposed surface water chamber with flow control device
- Proposed trapped road gully and 150mm diameter connection
- Proposed headwall

NOTES

1 Surface water channel outlet locations shown as preliminary.

2 For details of the network shown refer to the Design Criteria Report

3 The filter drains to the Private Means of Access and to the Cycleway are shown indicative only.

RHIF NO.	NEWIDIADAU MODIFICATIONS	GAN BY	DYDDIAD DATE	GWIRIWYD CHECKED

YGC RLEA FCERM

CYNGOR GWYNEDD COUNCIL

CYNLLUN / SCHEME :

A55 Tai'r Meibion to Abergwyngregyn Junction 12 to 13 Improvements

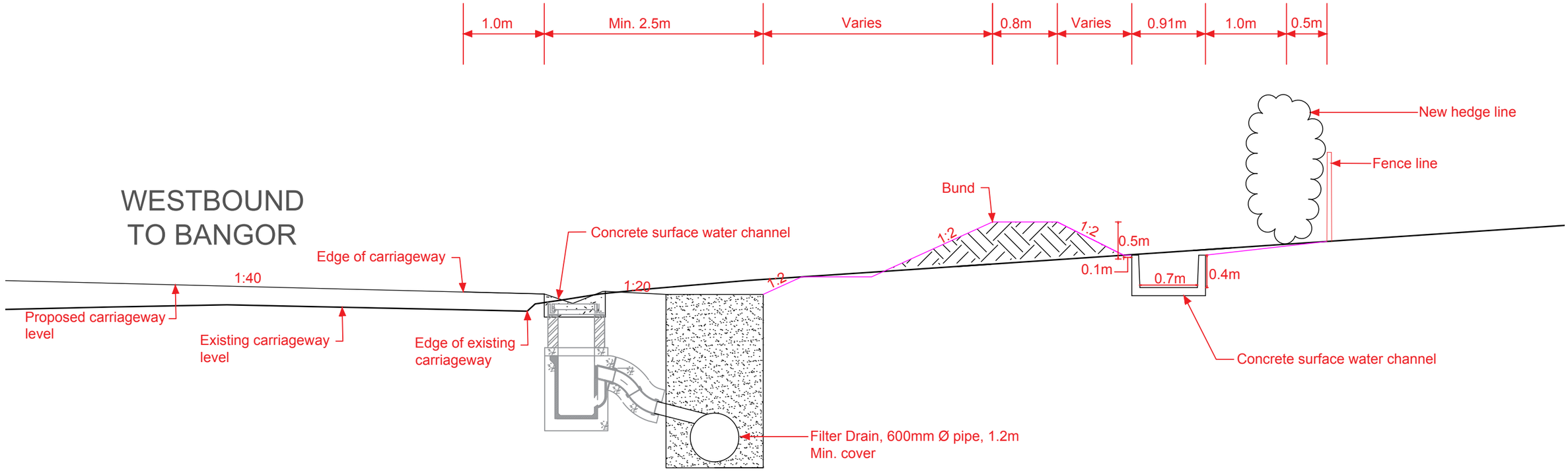
TEITL LLUNIAD / DRAWING TITLE :

Drainage Drawing 9

DARLUNIWYD GAN : DRAWN BY :	EH	DYDDIAD DARLUNIWYD : DATE DRAWN :	24/09/2015
GWIRIWYD GAN : CHECKED BY :	RW	DYDDIAD GWIRIWYD : DATE CHECKED :	25/09/2015
Taflen Sheet	9 of 9	GRADDFEYDD : SCALES :	1:500@A1

Rhif Lluniad Drawing No. 5055 DR 09

CYWI REV A



CYNLLUN / SCHEME : 5055 A55(T) Abergwyngregyn to Tai'r Meibion Improvement	DARLUNWYD GAN / DRAWN BY : SW	DYDDIAD DARLUNWYD / DATE DRAWN : 27/01/2016	YGC RRLEA FCERM
	GWIRIWYD GAN / CHECKED BY : RW	DYDDIAD GWIRIWYD / DATE CHECKED : 27/01/2016	CYNGOR GWYNEDD COUNCIL
TEITL LLUNIAD / DRAWING TITLE : Edge of carriageway drainage Bund detail	Taflen / Sheet 1 o / of 1	GRADDFEYDD / SCALES : 1:50 @ A3	
	Rhif Lluniad / Drawing No.	CYWI REV A	

K:\5055 A55 ABER TO TAI'R MEIBION 2015\XSECS\TYPICAL DRAINAGE SYSTEMS XSECS STANDARD DETAIL.DWG
07/04/2016 11:17:58

Asiant Cefnffyrdd Gogledd a Chanolbarth Cymru
North & Mid Wales Trunk Road Agent

ABER TAI'R MEIBION ROAD CROSSING'S DRAINAGE REPORT

YGC

PIPE DRAINAGE CROSSING LOCATIONS

CROSSING 1 DETAILS

Westbound verge MH 1 Catch pit Details

Outlet 12.00 o'clock 220mm PVC.
Inlets 3.00 o'clock 300mm PVC, French drain carriageway verge.
Inlet 5.00 o'clock 150mm PVC, carrier from top of cutting, French drain.

JPG 0949

JPG 0950

Catch Pit 1 Outlet details to Centre Reservation MH 2.

Outlet 220mm PVC crossing carriageway to centre reservation MH 2
Centre Reservation MH 2, 9 o'clock inlet concrete, 3 o'clock Inlet concrete,
Outlet 300mm PVC to MH 2A.
JPG 015 down Stream photo Into Centre Reservation MH 2.
JPG 012 / 013 up Stream Photo into Centre Reservation MH 2.
CCTV Video Footage 014 folder March 23rd MH 1 Catch Pit to MH 2 down Stream, no defects identified.

JPG 015

JPG 012

JPG 013

MH 2A DETAILS

Inlet 3 o'clock

JPG 009

Outfall Details, Crossing 1

Outfall 300mm PVC
CCTV Video Footage 008 file March 23rd Outfall Up Stream
To MH 2A and MH 2 Centre Reservation
No defects identified in crossing.

JPG 0947

JPG0946

CROSSING 2 DETAILS

CULVERT INLET DETAILS

OUTLET 900mm CONCRETE.
Small amount of debris 0 CH to CH 10.
Video Footage 003 folder March 23rd down Stream to MH 3 / MH 4.

JPG 0944

JPG 0945

MH 3 DETAILS CENTRE RESERVATION

INLET 3 O'CLOCK CONCRETE
No access to identify internal pipes dimension.

JPG 005

MH 4 EASTBOUND VERGE DETAILS

.

Unable to access for internal inspection
No defects identified on crossing.
Video footage 003 folder March 23th.

JPG 004

.

CROSSING 3 DETAILS

CULVERT INLET HEADWALL

Small amount of debris at start of run.
Video footage 016 March 23rd folder upstream to inlet.

Video 016

Inlet Headwall

MH 5 CENTRE RESEVATION

No access to identify internal pipes dimensions.
Inlet 9 o clock,
Overflow outlet 3 o 'clock to MH 8

JPG 017

Outfall Details, Crossing 3

Outfall 800mm concrete.
No defects identified in crossing.
Video footage 016 folder March 23rd upstream to MH 5.

Jpg 016

CROSSING 4 DETAILS

MH 7 DETAILS

Inlet 450mm PVC change to 450mm concrete upstream to MH 8.
Outlet 450 PVC changing to 450 concrete.
No defect identified upstream.

JPG 0954

JPG 0953

Video 022

MH 7 TO OUTFALL

Outfall 450mm concrete
No defects identified
Outfall location 22.5 Mtr downstream from MH 7.
Video footage 026 March 23rd file.

Video 026

MH 8 DETAILS, CENTRE RESERVATION

Unable to access to identify internal pipe dimensions.
Inlet 3 o' clock concrete.
Overflow Inlet from MH5 at 9 o 'clock.
Video footage 022 folder March 23rd
No defects identified.

Video 022

CROSSING 5 DETAILS

MH 9 TO INLET, DETAILS

Inlet 350mm concrete.
Inlet 3 Mtr 2 o'clock clay 150mm? photo 1
Inlet or fracture 7.30mtr @ 12 o'clock photo 2
Inlet @ 10.50mtr 12 o'clock 150mm? Clay photo 3
Roof rupture @ 15.5mtr 12 o'clock, photo 4
Abandoned survey due to debris and joint displacement Photo 5.
MH 9 upstream to inlet, video footage 001 March 24th

Photo 0955

Photo 0956

Photo 1

photo 2

Photo 3

photo 4

Photo 5

MH 9 OUTFALL DETAILS

Stone box culvert, outfall unknown possible Wig bach stream.
Unable to CCTV.
JPG 007 /008
Video file March 24th

JPG 008

INLET & HEADWALL DETAILS

Inlet 350mm concrete photo file 2016

JPG 057

JPG 058

JPG 059

CROSSING 6 DETAILS

MH 10 TO INLET

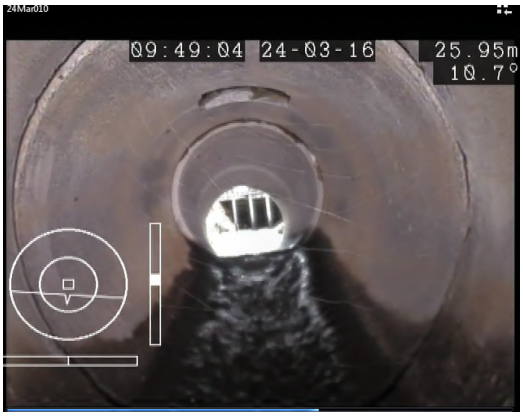
MH10 JPG 0966
Inlet 350mm concrete jpg 0965 .
Video footage upstream 001 March 24th
Hole in pipe 6 o'clock @25mtr see video footage 001 March 24th
Possible inlets 12 o'clock 26.5 mtr see video footage 001 March 24th

JPG 0966

JPG 0965

Video 001

Video 001



MH 10 OUTLET DETAILS

Stone box culvert changing to pipe downstream, unable to CCTV.
Outfall location Wig Farm pond.

JPG 016

INLET & HEADWALL DETAILS

Inlet 350mm concrete photo file 2016

JPG 0961

JPG 0960

CROSSING 7 DETAILS

OUTFALL DETAILS

Upstream video footage 017 March 24th.
Possible MH 11 centre reservation.
No access to identify internal pipe dimensions.
Inlets 3 o'clock see photo 018 video file March 24th 2016.
Inlet 9 o'clock see photo 018 video file March 24th 2016.
Outfall pipe 1050mm concrete jpg 0967 file photo 2016.
No defects identified.

JPG 0967

JPG 0968

VIDEO 018

INLET DETAILS

PIPE 1050MM
Photo file 2016

JPG 0963

CROSSING 8 DETAILS

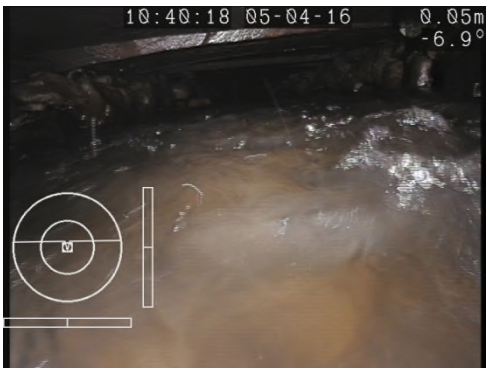
MH 12 CATCH PIT DETAILS

Catch pit full of stones, requires emptying.
Inlet pipe 6 o'clock 600mm concrete.
Outlet 12 o'clock stone box culvert 480mmx250mm JPG 004.
Unable to CCTV downstream from outlet.

PHOTO 0984

PHOTO 0985

JPG 004



M12 TO MH13 CROSSING

No defects in pipe crossing
Possible collapse around MH13 UTO jpg 0988
MH13 location jpg 0996
Video footage from MH 12 TO MH 13 video file 001 April 5th.
Internal photo MH 13 photo 003 video file April 5th

Jpg 0988

Jpg 0996

Photo 003

CROSSING 9 DETAILS

MH 14 DETAILS

MH14 location jpg 0986/0987 file photo 2016
Inlet 6 o' clock 225mm clay.
Inlet 9 o'clock 380mm concrete.
Outlet 12 o'clock 380mm concrete.

Photo 0986

Photo 0987

MH 14 TO MH 15 CROSSING DETAILS

Video footage 013 file April 5th.
Condition ok some minor joint displacement.
Inlet 9 o'clock @31.5mtr possible 150mm clay photo 014 file April 5th.
Chamber @42.7Mtr MH15 location unknown possible w/b/verge
Internal Photo 015 of chamber, file April 5th.

Photo 014

photo 015

MH14 TO MH 16 UPSTREAM DETAILS

Video footage 010 April 5th.
Large fractures @ 5.47 Mtr photo A, still from video.

Photo A

MH 14 OUTLET TO OUTFALL DETAILS

Video footage 006 April 5th file.
Pipe condition ok no defects.
Inlet @36.5Mtr 9 o'clock clay photo 007 file April 5th .
Chamber @91Mtr towards railway line, location unknown
Photo 008 April 5th file.

Photo 007

photo 008

CROSSING 10 DETAILS

MH16 TO MH 17

Video footage 010 April 5th file.
Roof collapse @ 9.5 Mtr photo 011 April 5th file.

PHOTO 001

MH 17 DETAILS

MH 17 Location bottom of embankment, boundary wall photo0991.
Inlet 6 o'clock 380mm concrete photo 0992.
Inlet 8 o'clock 380mm concrete photo 0992.
Outlet 380mm concrete to MH 16 photo 0992.

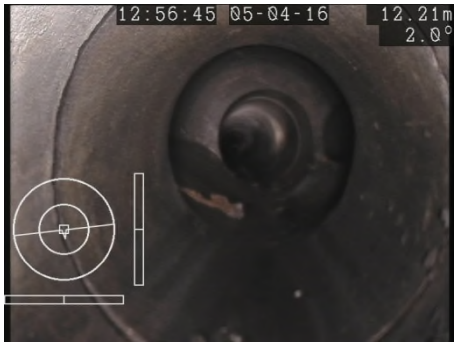
Photo 0991

photo 0992

MH 17 TO MH18 CENTRE RESERVATION

Video footage 016 April 5th file, MH 17 to MH 18.
MH 18 @13Mtr
Possible inlet 9 o'clock & 3 o'clock, no access to classify.
Internal photo of MH 18 018 April 5th file.
No defects identified.

Photo 018



MH 18 TO GULLY OUTFALL W/B KERB LINE

Inlet @ 14.5 Mtr 3 o'clock unable to identify dimensions possible 150mm
Photo 019.
Outfall from gully 150mm clay, photo 018.
No defects identified.

Photo 019

photo 018

MH 17 TO MH 19 CATCH PIT CENTRE RESERVATION

No defects identified.
Survey abandoned at MH 19 catch pit.
Video footage 021 April 5th file upstream to MH 19.
MH 19 no access to identify internal pipe dimensions, centre reservation.
Possible inlet 3 o'clock.
Possible inlet 9 o'clock.
Inlet 12 o'clock 380mm concrete from W/B verge catch pit.
Unable to access W/B verge catch pit to close to running lane.
Photo B, location of MH 19 catch pit centre reservation.
Photo 022 MH 19 internal.

Photo 022

photo B

CROSSING 11 DETAILS

OUTFALL DETAILS

Outfall pipe 1050mm.
Photo 0995 headwall.

Photo 0995

Headwall upstream to MH 20 inspection chamber

Video footage 023 April 5th file upstream to MH 20.
MH 20 inspection chamber @ 7.2 Mtr, unable to locate above ground.
Photo 024 April 5th file.
No defects identified.

Photo 024

MH 20 TO MH 21

Video footage 023 April 5th file.
Pipe dimension 1050mm
MH 21 inspection chamber @ 37.5 Mtr. Centre reservation.
Possible inlet @ 3 o'clock.
No defects identified.
Photo 025 April 5th file, MH 21.

Photo 025

MH 21 TO INLET

Video footage 023 April 5th file.
Pipe dimension 1050mm.
No defects identified.
Photo 026 inlet April 5th file videos 2016.
Photo 005 headwall, photos 2016 file.
Photo 004 inlet location, file photos 2016.

Photo 026

photo 005

Photo 004

CROSSING 12 DETAILS

INLET TO OUTFALL DETAILS

Pipe dimension 1050mm concrete.
Headwall photo 0969 file photos 2016.
Video footage 021 April 24th file video 2016.
Inlet @ 5Mtr 11 o'clock 350mm concrete photo 022 file photo 2016.
Inlet @ 13.24 Mtr 11 o'clock 350mm concrete photo 023 file photo 2016.
Outfall photo 024.
No defects identified.

Photo 0969

photo 022

Photo 023

photo 024

CROSSING 13 DETAILS

START OF RUN AT MH 22 DOWN STREAM TO MH 23

Location of MH 22 Hendra Hall slip, Google photo.
MH 22 photo 0975 file photo 2016.
MH 22 inlet 6 o'clock 600mm concrete photo 0974 file photo 2016.
MH 22 outlet 560mm steel, photo 0971 file photo 2016.
Unable to CCTV down to MH23 steep gradient down embankment.

Google photo

photo 0975

Photo 0974

photo 0971

MH 23 TO MH 24 DETAILS

Location of MH 23 W/B verge photo 0977 file photo 2016.
Video footage 001 April 4th file video 2016 poor footage due to technical problem with camera, visual inspection appears ok.
Inlet 6 o'clock 560mm steel photo 0976 file photo 2016.
Inlet 9 o'clock 380mm concrete photo 0976 file photo 2016.
Outfall 12 o'clock 1050mm concrete photo 0976 file photo 2016.

Photo 0977

photo 0976

MH 24 TO MH 25 DETAILS

Video footage 001 April 4th file, video 2016, poor footage due to technical problem with camera, visual inspection appears ok.
MH 25 location photo 0980 file photo2016
Inlet 6 o'clock 1050mm concrete photo 0978 file photo 2016.
Inlet 9 o'clock 380mm concrete photo 0979 file photo 2016.
Outlet 12 o'clock 1050mm concrete photo 0979 file photo2016.

Photo 0980

photo 0978

Photo 0979

MH 25 TO MH 26 INSPECTION CHAMBER

Video footage 001 April 4th file, video 2016, poor footage due to technical problem with camera, visual inspection appears ok.
Location MH 26 E/B embankment slip on slip off photo 0983 file photo 2016.
Inlet 6 o'clock 1050mm concrete photo 0982 file 2016.
Outlet 11 o'clock 1050mm concrete photo 0982 file 2016.
Outfall 1050mm concrete photo still from video.

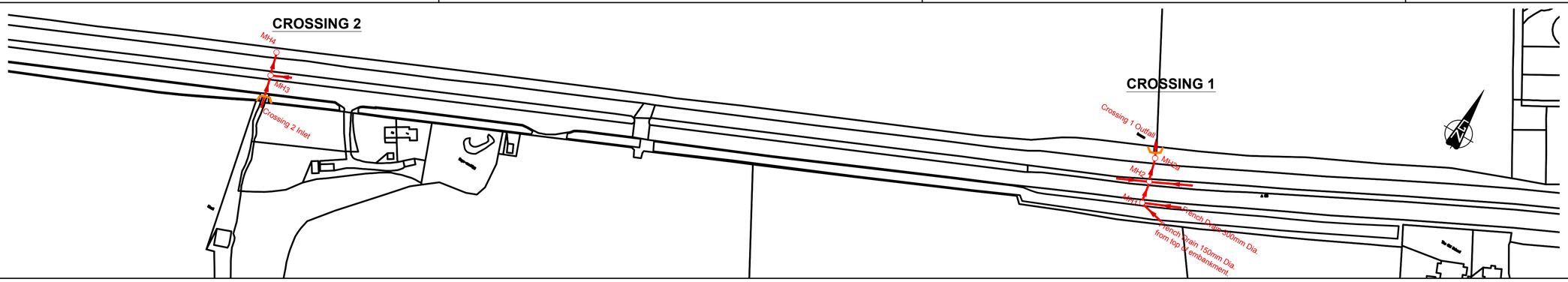
Photo 0983

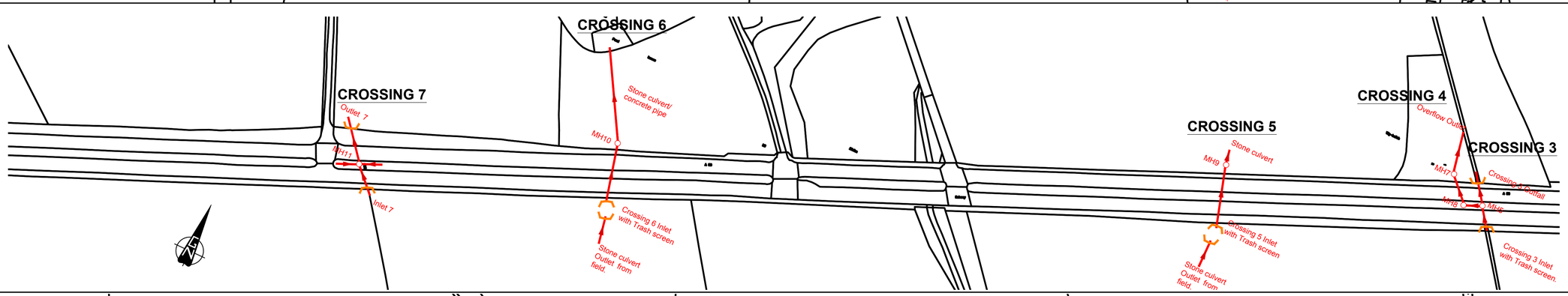
photo 0982

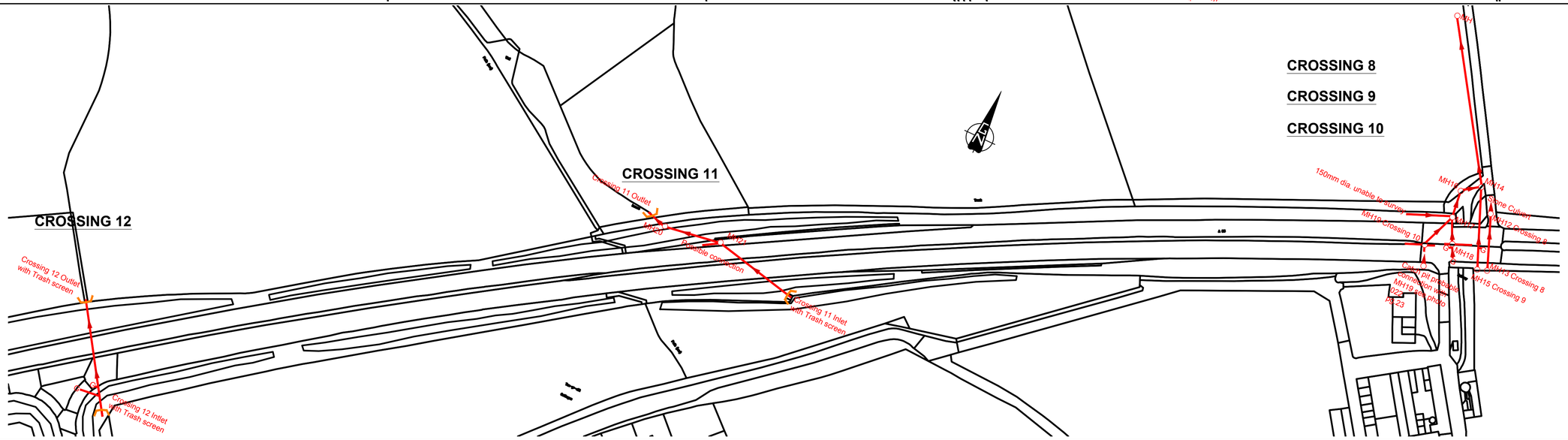
Still from video

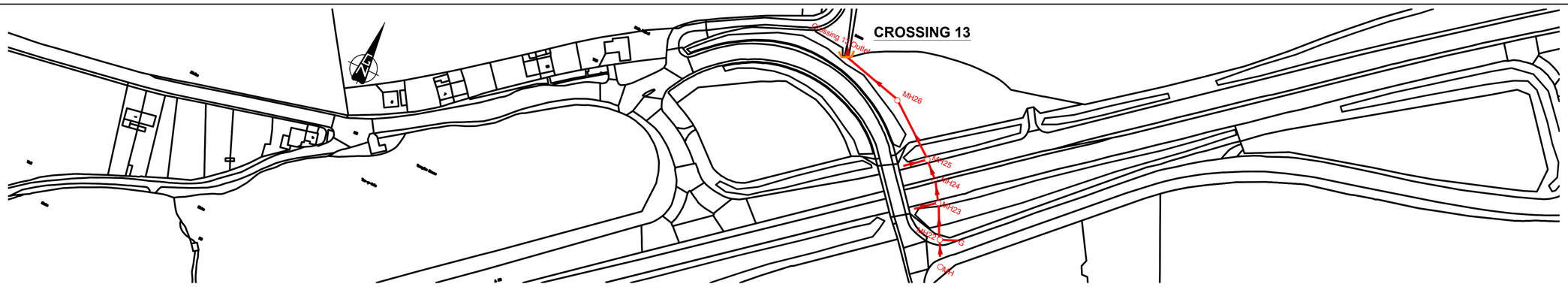
APPENDICES

APPENDIX A-Plan of Existing Drainage









CLEIENT/CLIENT :

NODIADAU/NOTES

RHIF NO.	NEWIDIADAU MODIFICATIONS	GAN DRAWN	GWIRIWYD CHECKED	DYDDIAD DATE

YGC Geo-Dechnegol Geo-Technical

CYNGOR GWYNEDD COUNCIL

CYNLLUN / SCHEME :

A55 Aber Tai'r Meibion 2015

TEITL LLUNIAD / DRAWING TITLE :

Aber Tai'r Meibion
Road Crossing's Drainage Report

DARLUNWYD GAN : DRAWN BY :	WRO	DYDDIAD DARLUNWYD : DATE DRAWN :	19/04/2016
GWIRIWYD GAN : CHECKED BY :	Monty	DYDDIAD GWIRIWYD : DATE CHECKED :	20/04/2016
Taflen Sheet	1 of 1	GRADDFEYDD : SCALES :	1:11250@A1

Rhif Lluniad Drawing No. 5055_DR_010

CYWI REV A

APPENDIX B –Drainage Schedule.

Drainage Schedule for Drawing No. 5055_DR_010				
Manhole Number	**Pipe Material**	**Pipe Diameter (mm)**	**Length (m)**	**Comments**
MH1 to MH2	Polyvinyl	220 (mm)	9.0	
MH2 to MH2a	Polyvinyl	300 (mm)	10.0	
MH2a to Outlet 1	Polyvinyl	300 (mm)	N/A	
Inlet 2 to MH3	Concrete	900 (mm)	10.0 (m)	Trash screen and debris.
MH3 to MH4	Concrete	□nknown (mm)	14.0 (m)	□nable to access.
Inlet 3 to MH5	Concrete	800 (mm)	10.0 (m)	Trash screen and standing water.
MH5 to Outlet 3	Concrete	800 (mm)	14.0 (m)	
MH5 to MH8	□nknown	□nknown (mm)	□nknown	□oth manholes in central reservation.
MH7 to MH8	Polyvinyl	450 (mm)	14.0 (m)	
MH7 to Overflow Outlet	Polyviny/ Concrete	450 (mm)	22.0 (m)	Material change at 1.0m.
MH9 to Inlet 5	Concrete	350 (mm)	30.0 (m)	Trash screen.
MH9 to Outlet 5	Stone	□ox culvert (mm)	00.0 (m)	□nable to survey□culvert outfall possible exit at Wig □ach stream.
MH10 to Inlet 6	Concrete	350 (mm)	26.0 (m)	Trash screen.
MH10 to Outlet 6	Stone/ Concrete	□ox culvert (mm)	00.0 (m)	□nable to survey□construction change midway□outfall at Wig Farm pond.
Outlet 7 to MH11	Concrete	1050 (mm)	17.0 (m)	
MH11 to Inlet 7	Concrete	1050 (mm)	11.0 (m)	Debris from central reservation inlets across main line.
MH12 to MH13	Concrete	600 (mm)	28.0 (m)	Loose stones in base of manhole.
MH12 to Outlet 8	Stone	480x250 (mm)	00.0 (m)	Culvert followed same line as farm track to railway crossing.
MH14 to MH15	□itrified Clay	225 (mm)	43.0 (m)	Cracks and line defects.
MH14 to Field MH	Concrete	380 (mm)	91.0 (m)	
MH16 to MH17	Concrete	380 (mm)	12.0 (m)	9.2m Roof collapse.
MH17 to MH18	Concrete	380 (mm)	06.0 (m)	
MH17 to MH19	Concrete	380 (mm)	18.0 (m)	Standing water.
Outlet 11 to MH20	Concrete	1050 (mm)	07.0 (m)	
MH20 to MH21	Concrete	1050 (mm)	30.0 (m)	
MH21 to Inlet 11	Concrete	1050 (mm)	45.0 (m)	
Inlet 12 to Outlet 12	Concrete	1050 (mm)	42.0 (m)	Trash screens on both Inlet and Outlet.
MH22 to MH23	Steel	560 (mm)	□nknown	□nable to survey□steep gradient.
MH23 to MH24	Concrete	1050 (mm)	□nknown	Tecnical lighting issues with camera video footage dark.
MH24 to MH25	Concrete	1050 (mm)	□nknown	Tecnical lighting issues with camera video footage dark.
MH25 to MH26	Concrete	1050 (mm)	□nknown	Tecnical lighting issues with camera video footage dark.
MH26 to Outlet 13	Concrete	1050 (mm)	□nknown	Tecnical lighting issues with camera video footage dark.