Appendix A.1 – Record of Determination

IAN 126/09 ANNEX A: Record of Determination, Welsh Government, Economy, Science and Transport Department. For use with Annex II relevant projects only

Name of project: A487 Caernarfon to Bontnewydd Bypass	**Location (including national grid reference):** Caernarfon and Bontnewydd, North Wales Grid Ref: SH495,620

Qualifying criteria for Annex II relevant project: (please tick which are relevant)

Improvement element of project is >1ha	✓	Project is located within 'sensitive' area	✓	Other with potential for significant effect (e.g. adjacent to sensitive site)	✓

A. Description of project:

The Scheme consists of a new 9.8km highway between the Goat roundabout (A499/A487 junction) and the Plas Menai Roundabout (A487 Junction). It forms a western bypass to Llanwnda, Dinas and Bontnewydd before crossing the existing A487 to pass south of Caernarfon Quarry. It then crosses the River Seiont, passes south of the Cibyn Industrial Estate to a junction with the A4086. After crossing the B4366 the route drops steeply to the Plas Menai Roundabout.A WS2+1 standard has been adopted consisting of 2 lanes of travel in one direction and a single lane in the opposite direction providing overtaking opportunities in the two lane direction while overtaking in the single lane direction is prohibited.There are nineteen structures comprising seven bridges (including a crossing over the Welsh Highland Railway, a 280m bridge over the River Gwyrfai and a 300m bridge over the River Seiont) and twelve culverts.In addition to the major construction there would also be on-line improvements to the existing trunk road. The latter consists of improvements to existing junctions, traffic management, parking restrictions and improving visibility at junctions.

B. Description of local environment, including statutory and non-statutory designations:

The Scheme is located within a rural setting dominated by agriculturally improved grassland and to a lesser extent arable land. There are patches of semi-natural broad-leaved and coniferous woodland, scrub, semi-improved grassland and marshy grassland. Numerous hedgerows are present along field boundaries. The Scheme crosses two major watercourses, namely the Afon Gwyrfai and the Afon Seiont, both of which drain into the Menai Strait, 2km west of the Scheme. This forms part of the Menai Strait and Conwy Bay Special Area of Conservation (SAC). The Afon Gwyrfai is bordered by steep-sided deciduous woodland, residential properties at Bontnewydd and agricultural fields. Where the Scheme crosses, the Afon Gwyrfai is designated as an SAC (the Afon Gwyrfai a Llyn Cwellyn SAC) and a Site of Special Scientific Interest (SSSI) (the Afon Gwyrfai a Llyn Cwellyn SSSI). The Afon Seiont is bordered by grassland (largely improved), a holiday park and steep-sided woodland. Part of the Afon Seiont, approximately 1km to the west of the Scheme, is also designated as a SSSI for its geological features. The Glynllifon SAC/SSSI, which is designated for its large lesser horseshoe bat population is located approximately 1.3km to the south of the Scheme. Rhyddallt Bach Waenfawr Road, Afon Seiont (middle), Afon Seiont Mosaic (North) were all candidate Wildlife Sites (non-statutory designations) crossed by the Scheme at the time of the Key Stage 2 Study. There are three Scheduled Ancient Monuments (SAMs) in close proximity to the Scheme: Bryn-Glas Roman signal station (SAM CN 188); Hut Circle, Rhyd-y-Galen (CN 229); and Caerlan Tibot defended enclosure (SAM CN 400). The Caerlan Tibot enclosure lies approximately 85m from the Scheme.

C. Summary of main environmental effects of project:

An initial environmental assessment was undertaken as part of the Key Stage 2 Study in 2009. The main potential environmental effects were identified as follows:

- Dust nuisance during construction. An overall decrease in air pollution levels for human receptors, but some increases where the Scheme moves closer to properties.
- Physical impact to a known Roman Road, an historic track and a Grade II listed milestone. Impacts on unknown archaeology. Indirect impacts to the settings of three SAMs and five Grade II listed structures
- Landscape and visual impacts are predicted
- Loss of habitats, potential impacts on protected species (such as bats, otters and reptiles) and potential impacts to protected sites (Afon Gwyrfai a Llyn Cwellyn SAC, Menai Strait and Conwy Bay SAC, Glynllifon SAC, Meirionnydd Oakwoods and Bat Sites SAC and Gwydir Forest Mines SAC)

DRAFT

- Potential impact on geological resources, mobilisation of ground contaminants, impacts to groundwater and hydrogeology.
- Production of waste, the use of materials and resources for construction and maintenance
- Construction noise and vibration. Increases in noise where the Scheme is brought closer to receptors and decreases where it moves further away.
- Severance of public rights of way. Relief from severance for communities along the existing A487 (e.g. Bontnewydd).
- Impacts to private land including agricultural businesses, a holiday park and Caernarfon Quarry. Loss of agricultural land.
- Potential pollution to watercourses and groundwater from site run-off, spillages and ground works during construction. Potential pollution to watercourses and groundwater from accidental spillages and Scheme drainage. Potential increased flood risk.
- There could be cumulative effects with other plans and projects

D. Details of extent of environmental impact assessment work undertaken and summary of any consultation undertaken with the statutory consultation bodies (including CADW, Natural Resources Wales and the relevant Local Authority):

During the Key Stage 2 Study (2009 – 2011) a DMRB Stage 2 EIA and WelTAG Appraisal was undertaken. Consultation with statutory consultees and other stakeholders was undertaken as part of this process.

Consultees during the Key Stage 2 Study included CCW, EA, Cadw, GAT, MWTRA and Gwynedd Council. An Environmental Liaison Group (ELG) meetings was held during the Key Stage 2 Study.

The ELG has reconvened and meetings will be held quarterly through Key Stage 3. The ELG will include: the Client Team (WG, EC Harris and Ramboll), the JV Team (Balfour Beatty, Jones Bros., Parsons Brinckerhoff and TACP), NRW (previously CCW, EA and the Forestry Commission in Wales), Cadw, NMWTRA, Gwynedd Council and GAT.

E. Determination decision, statement of case in support of this decision as to whether EIA is/is not required:

The A487 Caernarfon to Bontnewydd Bypass is an Annex II 'relevant project' as defined by the Highway (Assessment of Environmental Effects) Regulations 1999. In considering it against the criteria listed in Annex III of Council Directive 2011/92/EU[1] an Environmental Impact Assessment is required. This is due to the characteristics of the project to include its size, the use of natural resources to construct and maintain it, production of waste associated with its construction and potential pollution and nuisance caused etc.); its location and the characteristics of potential impacts as identified in C. above.

File references of supporting documentation for future reference:

Parsons Brinckerhoff (2011) *A487 Caernarfon – Bontnewydd Study – DMRB Stage 2 Environmental Impact Assessment*. Welsh Government

Parsons Brinckerhoff (2009) *A487 Caernarfon – Bontnewydd Study – Technical Appraisal Report.* Welsh Government.

Welsh Government (2012) *A487 Caernarfon to Bontnewydd Bypass – Works Information*

I have determined, following discussions with the Welsh Government's / Trunk Road Agent's Environmental Advisor that a statutory Environmental Impact Assessment is required for this project.

Signature Project Director: Dated:

Authorisation to publish Notice of Determination:

Signature Welsh Ministers' Nominee: Dated:

[1] Directive 2011/92/EU was revised by Directive 2014/52/EU in March 2014. Member states have a three year period in which to transpose the legislation into their domestic legislation. Requirements of the revised Directive need not be implemented until Spring 2017

DRAFT

FIGURE 1. – STRATEGIC CONTEXT (TAKEN FROM NATIONAL TRANSPORT STRATEGY 2008)

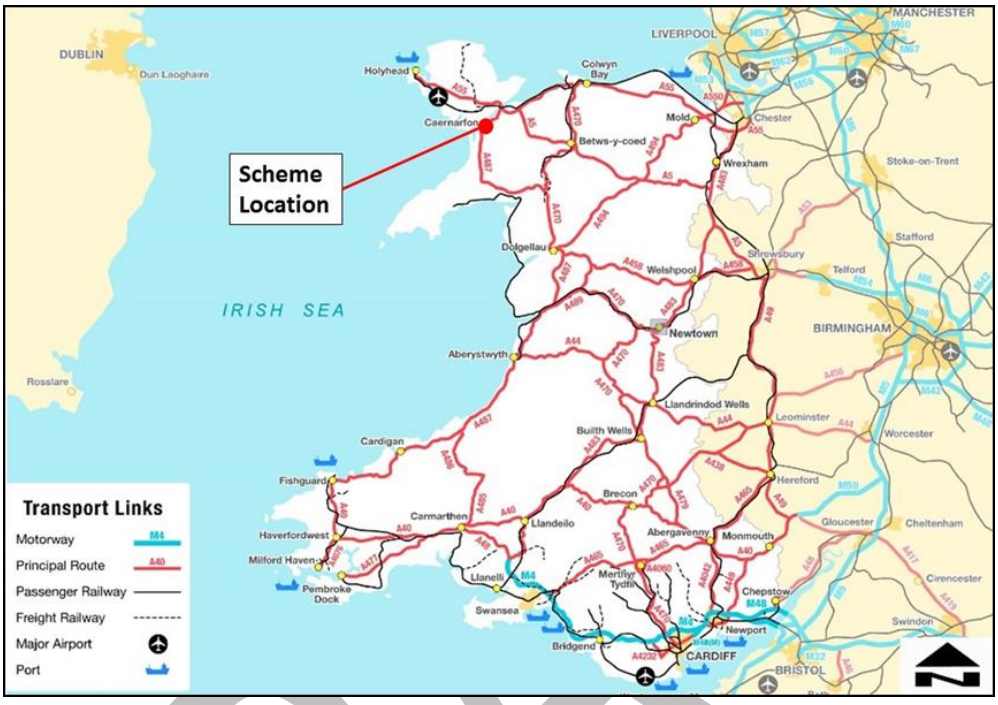
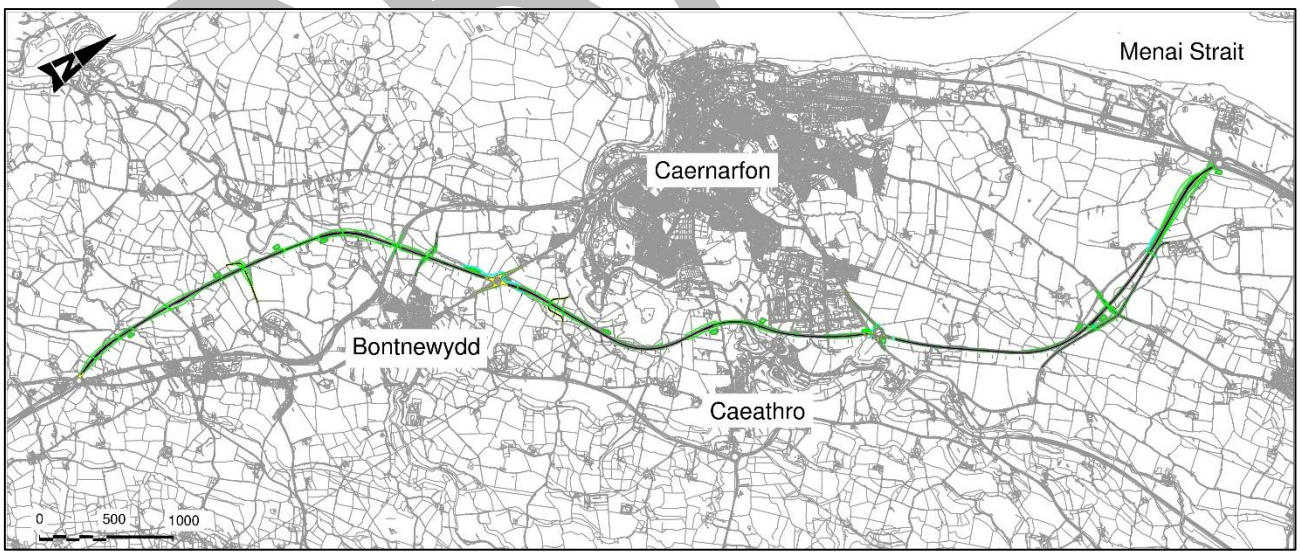


FIGURE 2. – GENERAL SCHEME LAYOUT



Appendix A.2 – Scoping Response

A487 Caernarfon to Bontnewydd Bypass

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris

Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comments status key: **C** = Comment, **OBS**=observation only **CFA** = Comment for future action

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
1a	DH (NRW)	Thank you for your consultation received on the 3rd of March 2015 referring to the above proposal. Natural Resources Wales brings together the work of the Countryside Council for Wales, Environment Agency Wales and Forestry Commission Wales, as well as some functions of Welsh Government. Our purpose is to ensure that the natural resources of Wales are sustainably maintained, used and enhanced, now and in the future. We are generally satisfied with the proposed content of the Environmental Statement (ES) but we have listed below certain items that should, in our view be included or clarified. These are as follows:-	OBS	MB	Noted.		

A487 Caernarfon to Bontnewydd Bypass

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
2a	DH (NRW)	**Flood Risk** A Flood Consequence Assessment is to be prepared in accordance with TAN15. Structures crossing main rivers should have a minimum freeboard of 600mm above the design flood level (1 in 100 or 1% AEP + 20% for climate change). Balancing ponds should be designed to cater for the 1 in 100 year rainfall event (with due consideration given to climate change) with Greenfield run off rates maintained. Flood Defence Consents will need to be submitted under the requirements of Section 109/201 of the Water Resources Act 1991 for the main rivers crossings/diversions. We also consider that the following paragraphs require comment in terms of flood risk:-	C	CS	A FCA will be prepared to accompany to ES. Freeboard requirement noted and will be incorporated into the design & FCA.		
3a	DH (NRW)	5.11.4 - should read ".....or flood risk increased, elsewhere." (rather than "....or flood risk increased, downstream.")	C	CS	Noted. The FCA will assess impacts both upstream & downstream of the site		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
4a	DH (NRW)	5.11.8 - The Land Drainage Act 1991 should also be listed.	C	CS	Noted. List will be updated to include this reference		
5a	DH (NRW)	5.11.9 - The scheme crosses (or will affect) 7 number designated main rivers. These are- • Afon Rhyd @ NGR SH4716558272 • Afon Plas @ NGR SH4723159119 • Afon Gwyrfai @ NGR SH4732559738 • Afon Rhosdican @ NGR SH4788160487, SH4833860775, SH4843560846 & SH4885560996 • Afon Seiont @ NGR SH4959762124 • Afon Cadnant @ NGR SH5101264273 & SH5107164320 • Afon Cadnant Trib @ NGR SH5103364491 & SH5099564681	C	CS	Scoping report will be amended to reflect the other Main River crossings. It was agreed with NRW at the meeting on 18th February 2015 that the smaller Main River crossings (i.e. not the Seiont, Rhyd and Gwyrfai) would not need full modelling and a qualitative assessment would be sufficient for the FCA.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
6a	DH (NRW)	5.11.1 - See 5.11.9 above	C	CS	Do not understand comment. This paragraph simply states what the ES chapter covers.		
7a	DH (NRW)	5.11.39 - any temporary structure e.g. temporary bailey bridges likely to affect the flow (normal or flood flows) should be supported by hydraulic assessment to demonstrate that the flood risk is acceptable Please also note that site compounds, etc. should be located outside of any flood zones.	C	CS	Noted. If necessary, temporary works hydraulic assessment will take place at a later stage in the project. The FCA & ES will consider the impact of temporary works however it is not expected that sufficient information will be available to undertake hydraulic assessment or modelling at this stage. Location of proposed temporary compounds will be reviewed as part of the FCA. Need to confirm what detail of information is available for temporary works and if more detailed assessment should be undertaken for the ES / FCA.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
8a	DH (NRW)	**<u>Water Framework Directive</u>** We welcome the intention stated in Section 5.11.23 to incorporate a Water Framework Directive compliance assessment within the ES. This should also assess geomorphological impacts and include waterbody crossings designs that will allow for lateral movement of river channels in the future.	C	CS	Noted. WFD assessment will include qualitative assessment of geomorphological impacts. Potential lateral movement of channels will be considered in the development of the design.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris

Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
9a	DH (NRW)	**<u>Nature Conservation</u>** Under Proposed level and Scope of Assessment (Sections 5.5.19 and 5.5.20), reference is made to the assessment of implications on European sites and of the possible need for appropriate assessment, it is important to note that these assessments are required in order to comply with the Conservation of Habitats and Species Regulations 2010 (as amended). It should also be noted that the definition of significant impact quoted in Section 5.5.53 and the levels of the significance of impacts provided in Table 5.5.1 do not necessarily apply to the assessment of 'significant effect' referred to in Regulation 61 of these regulations (We also note that the 'interim' document referred to in Section 5.5.20 was to be withdrawn when the 1993 guidance was republished, so this may no longer be valid).	C	SS/MB	Noted – the assessment criteria for any AA work will be defined within the necessary documents, they have not been included here to avoid confusion between the different assessment criteria. Note that IAN 130 (Ecology and Nature Conservation: Criteria for Impact Assessment) is still current as there has not been an update to DMRB Vol. 11, Sec 3, Part 4.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris

Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
10a	DH (NRW)	We welcome the plan to use clear span bridges (referred to in various sections), rather than culverts as these are likely to provide improved habitat connectivity once the road is in place. However, assessments should also take account of potential risks and impacts during construction, for example, those associated with temporary bridges, or other structures that might affect riverine species and protected sites. All such construction impacts should be properly assessed.	C	SS	Noted		
11a	DH (NRW)	Minor watercourses should be surveyed for water vole presence, rather than following the recommendation in 5.5.84.	C	SS	Noted – these surveys will be incorporated into the programme for this year		
12a	DH (NRW)	In Section 1.6 – Policy context – there is no reference to biodiversity, local Biodiversity Action Plans or policies specific to duties under the Natural Environment and Rural Communities (NERC) Act 2006.	C	SS	We will address this in the ES and ensure that these are included		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
13a	DH (NRW)	In Section 2.4, Objectives, there are no biodiversity objectives stated for the scheme.	C	MB	Section 2.4 relates to the overall Scheme objectives which are derived from those developed during the Key Stage 2 Study using the Welsh Transport and Appraisal Guidance (WelTAG). The ES will consider the impacts of the Scheme against objectives of policies and plans relating to biodiversity (e.g. LBAP, TREBAP etc.)		
14a	DH (NRW)	Lighting, the 'minimisation' of which is a suggested mitigation measure in Section 5.4.38 in the landscape context, should also be considered in terms of its potential impact on protected species, particularly with reference to otters and bats.	C	SS	Noted – this will be included within the impact assessments for all nocturnal species		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
15a	DH (NRW)	With regard to the timing of in-stream works, we agree with Section 5.5.96 that in-stream construction should avoid the period 1st of October to 1st May to avoid impacts on salmonid spawning areas. In addition to matters concerning salmonids, sea lamprey are known to spawn on the Afon Seiont in spring (below Cibyn Ind. Estate area), and are likely present in the Gwyrfai and / or other streams, alongside other lamprey species.	C	SS	Noted		
16a	DH (NRW)	**Bio-Security** We welcome the intention stated in Sections 5.5.63 and 5.5.93 to survey for non-native species. In our view as well as a survey for any invasive non-native species, including Himalayan balsam and Japanese knotweed, the ES should include a bio-security risk assessment for such species to account for potential risks to protected sites and species.	C	SS/MB	Noted. This will be included as part of the contractor's Construction Environmental Management Plan (CEMP)		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
17a	DH (NRW)	A management plan for invasive species control should be agreed / verified with NRW so that it can be implemented at the earliest opportunity.	C	SS/MB	Noted. This will be included as part of the contractor's Construction Environmental Management Plan (CEMP)		
18a	DH (NRW)	**Groundwater and Land Contamination** We recommend that the following are included within any Environmental Statement or Environmental Impact Assessment: 1. Water feature survey – with a distance of 300m either side of the proposed road route (see details below).	OBS	ML	All controlled waters receptors will be identified through a desk based study and supplemented with a field survey where further information is required which will include: Surface waters, springs, wells, boreholes, ditches, ponds, lakes etc.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

19a	DH (NRW)	The developer must undertake a preliminary site assessment, which should include the following: • Identification of all water features both surface and groundwater (ponds, springs, ditches, culverts etc.) within a 300 metres radius of the site. • Use made of any of these water features. This should include the construction • details of wells and boreholes and details of the lithology into which they are installed; • An indication of the flow regime in the spring or surface water feature, for example whether or not the water feature flows throughout the year or dries up during summer months; • Accessibility to the spring/well; • This information should be identified on a suitably scaled map (i.e. 1:10,000), tabulated and submitted to Natural Resources Wales. It would be useful for	C	ML	A hydrogeological desk study is currently being completed which provides a detailed review of water resource along the proposed corridor. It will also include the results of a 'Private Abstraction Survey' which will identify all current and historic springs, wells and boreholes in use or historically used for water supply. Records have been requested and received from Natural Resources Wales and an outstanding freedom of information request is with Gwynedd Council requesting all information they have about abstractions. A letter has been drafted to be issued to all landowners affected by the development along with a marked plan of all known locations which aims to answer the first 5 bullet points. A copy of the letter and an example plan		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
		the developer to photograph each of the identified water features during the survey.			can be made available on request. This will be followed by meetings with landowners and a site survey		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

20a	DH (NRW)	Based on the results of the survey the applicant must assess the likely impacts from the development on both quantity and quality of the surface water and groundwater. This should take into consideration both the preferred methods of construction and the assumed hydrogeology in the vicinity of the development.	C	ML / CS	(ML) Using the Hydrogeological desk study information, the results of the private abstraction survey and construction information, the potential risk of the development on each location will be assessed and a list of features to be monitored prior, during and following construction will be formulated. Suites of chemical laboratory monitoring will be developed. Justification of features to be included or not included will be forwarded to Natural Resources Wales for comment prior to monitoring beginning. (CS) FCA & ES will consider the impacts of the scheme on the quantity and quality of runoff to local surface water features & groundwater in accordance with the DMRB methods described in the scoping report. The assessment will take account of		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
					mitigation incorporated into the design, i.e. SUDS, flow attenuation & pollution containment.		
21a	DH (NRW)	Natural Resources Wales may require identified groundwater features to be monitored during the proposed workings. We would therefore recommend that the survey be undertaken as soon as possible to enable the developer to carry out suitable baseline monitoring prior to the commencement of workings at the site.	C	ML	Baseline monitoring will commence approximately 1 year prior to construction to allow baseline monitoring and observe for any seasonal trends in both water quality and quantity.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
22a	DH (NRW)	Preliminary risk assessment – to determine the extent any land contamination (brownfield sites). This should also consider a 300m distance either side of the proposed road route (see details below).	C	ML	The PSSR identified all known or suspected contaminated land features. A Freedom of Information request is also outstanding with Gwynedd Council to establish any data they hold on the identified landfills as well as any other contaminating features. Ground Investigation at specific areas of the route will also be observed by a qualified contaminated land consultant.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
23a	DH (NRW)	Natural Resources Wales recommends that developers should: • Follow the risk management framework provided in CLR11, Model procedures for the management of land contamination, when dealing with land affected by contamination. • Refer to the Environment Agency Guiding principles for land contamination for the type of information required in order to assess risks to controlled waters from the site. The local authority can advise on risk to other receptors, e.g. human health. www.naturalresourceswales.gov.uk www.cyfoethnaturiolcymru.gov.uk Page 4 of 7 • Refer to the Environment Agency website at www.environment-agency.gov.uk for more information.	C	ML	Following the identification of any SPR linkages in the preliminary risk assessment, where relevant a generic quantitative risk assessment or detailed quantitative risk assessment for either controlled waters or human health will be completed. The principles of CLR11 will be adhered to throughout the process. The existing G.I will identify contaminated land where present in the vicinity of the proposed road and the extent and potential impact of contaminated land will be reviewed following this phase of work.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris

Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
24a	DH (NRW)	**Rivers, streams and watercourse crossings** All river and stream crossings should be designed to minimise disruption to the watercourse and maintain a natural bed to the watercourse and wherever practicable be clear span structures. Where culverts are required to accommodate wildlife e.g. otters, bats etc. these should not compromise the primary watercourse requirements and features.	C	CS	Noted and will be considered in the design development.		
25a	DH (NRW)	It is encouraging to see under 5.5.95 that the viaduct over the Afon Seiont will be set back at least 7m from either side of the watercourse. We would encourage similar approach wherever possible.	C	CS	Noted although original reference in Scoping report was to the Gwyrfai, not the Seiont. Set back will be considered in design development		
26a	DH (NRW)	**Drainage and Pollution Prevention** We welcome the intention to implement sustainable drainage systems (SuDS) within the scheme.	OBS	CS	Noted.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
27a	DH (NRW)	NRW encourages the use of soft SuDS in the management and treatment of run-off as close to source as possible. This could be through the use of filter strips, filter drains, swales, over edge drainage, retention ponds and detention basins these will also assist with balancing of run-off from the drainage.	OBS	CS	Noted and will be considered in the scheme design.		
28a	DH (NRW)	Due to the sensitivity of the receptors from this scheme the drainage system must include pollution containment as part of the primary design. Areas that are considered particularly vulnerable to incidents or impacts from incidents are junctions, roundabouts and larger river crossings. Access to containment locations in the event of an incident and for maintenance purposes should also be considered as part of the primary design process.	C	CS	Noted and will be considered in the scheme design.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
29a	DH (NRW)	Continuous kerb drainage systems e.g. 'Envirodrain' provide a practical solution in some situations such as bridges, viaducts, junctions and roundabouts. Whilst these function well as drainage conduits if used then the system must have suitable pollution control measures incorporated into the scheme drainage design as sealing the system in the event of an incident is not easily achievable.	C	CS	Noted and will be considered in the scheme design.		
30a	DH (NRW)	When designing the drainage system for the road it must be designed to maintain catchment separation i.e. not take run-off from one catchment and drain it to another.	C	CS	Noted and will be considered in the scheme design. Current drainage design maintains catchment separation.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
31a	DH (NRW)	A full pollution prevention and mitigation plan must be produced, agreed with NRW and implemented prior to commencement of the main construction works for the bypass scheme. The pollution prevention plan should cover all aspects and include silt management from all potential sources, oil, chemical, plant and material storage and management.	C	MB	Noted. The ECI contract requires that the contractor produces and implements a 'pollution control and contingency plan' as part of their overall Construction Environmental Management Plan (CEMP). This will cover the all appropriate aspects including those listed opposite.		
32a	DH (NRW)	**Material management** It is noted that in Section 5.7 the report states that a materials and site waste management plan will be produced for the scheme.	OBS	MB	This is a requirement of the ECI contract.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

33a	DH (NRW)	The scheme design should endeavour to achieve a balanced use of materials over the whole scheme to minimise any waste generation. If excess material is generated then management could be thorough identifying other developments where these may be utilised, this being done prior commencement of works on site. This will allow the consideration of other materials management options such as the CL:AIRE or aggregates protocols.	C	PT	Our current construction strategy is predicated on achieving a balance of earthworks material throughout the project. Topograhical survey and ground investigation works are currently ongoing which will more accurately confirm the quantities of the various grades of materials arising. The vertical alignment of the scheme will then be adjusted to balance the earthworks against the confirmed quantities. An assumption has currently been made on the level of unsuitable (but inert) material that may arise and provision has been made for the use of this material in “return to agriculture” areas adjacent to embankments throughout the scheme. This facilitates the return to farmland of greater areas of land than would otherwise be possible.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
					The strategy also makes use of the large quantities of rock arising from the north end of the scheme. We currently envisage that all premium aggregates other than those needed for structural concrete will be sourced from site, removing the need for bulk importation.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
34a	DH (NRW)	Storage of materials during the construction period must be planned and properly managed to ensure that any silt laden runoff does not enter any watercourse. Any materials stored during the construction phase, e.g. inert material, should be stored outside of the floodplain, and in a manner that will prevent discoloured water from entering any watercourses.	C	PT	Storage of bulk materials will be managed in specific areas. Each area will be the subject to the controls which will be managed via a Pollution Control Plan. We currently only envisage storage on the site of topsoil and processed stone. Stone will be stored in one area and only taken out on to site when required – within the storage area measures to control water run-off by ditching and ponds will be implemented. Topsoil stores will be seeded to prevent run-off.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
35a	DH (NRW)	**Ground investigations** 5.6.13 indicates a need for intrusive ground investigations, should these involve drilling that may result in slurry being produced then this must be fully contained.	C	KP	Rotary coring will be required to complete the ground investigation, if water flush is adopted this shall be used with a re-circulation system to prevent harm to the environment. If air mist is adopted steps shall be adopted to prevent the migration of flush debris away from exploratory hole locations. This shall include the use of boards/sheeting around drill sites to provide protection to the environment.		
36a	DH (NRW)	**Environment monitoring plan** In terms of potential contamination issues, an environment monitoring plan should be produced and agreed with NRW with appropriate implementation prior to commencement of works on site.	C	MB	Noted. This would form part of the overall CEMP for the Scheme.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
37a	DH (NRW)	**Incident reporting** Please note that any incident that may result in any environmental impact or detriment must be reported immediately to Natural Resources Wales on the incident hotline 0800 807060 providing, date, time, location, description of incident, impact or potential impact, any mitigation already implemented along with a contact name and phone number.	C	MB	Noted. All incidents would be reported to NRW. Procedures for incident reporting would be set out in the contactor's CEMP.		
38a	DH (NRW)	**Landscape** Methods- Interim Advice Note 135/10 (W) provides the most recent guidance on Landscape and Visual Effects Assessment for road schemes within Wales and needs to be referred to in any subsequent assessment.	C	PMc	We acknowledge this point and will incorporate the reference and requirements within the revised scoping report and ES.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
39a	DH (NRW)	Regarding Table 5.4.2, landscape / townscape value – the criteria set out in the table for landscape of Exceptional and Very Good value are the same. We would have expected to see some differentiation between these categories.	C	PMc	This is a drafting error. The criteria for Very Good is incorrect and should read as follows: Strong landscape structure; Composed of generally harmonious components; Distinct landscape characteristics, identity or patterns; Identifiable features worthy of retention; Occasional or minor detractive elements; This will be included in the revised scoping report and ES.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris

Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
40a	DH (NRW)	Visual Impact Assessment – The additional step of 'scale of visual impact' proposed in the assessment of visual effects is a departure from the steps set out in the GLVIA3 Figure 1.6. Whilst GLVIA3 is not prescriptive and landscape consultant's adaptation of the approach is common place, we are concerned that the proposed methodology with use of additional terminology which appear similar but with different meaning, could make the transparent and logical presentation of the assessment of visual effects difficult to follow. A worked example, with proposed reporting format for presenting the assessment would be useful in helping to clarify the approach.	C	PMc	Our proposed assessment process recognises separately the sensitivity of individual views (derived from their susceptibility to change and their value) and the sensitivity of the different receptor types. This staged approach provides clarity, in order that the assessment of visual impact significance is fully transparent and auditable. This methodology was applied to the recent Newtown Bypass EIA, and has been reviewed and agreed with NRW and the other Statutory Environmental Bodies. The landscape chapter is attached providing an illustration of the methodology and its presentation.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
41a	DH (NRW)	**Environmental Clerk of Works** In our view there should be an undertaking to appoint an environmental clerks of works to ensure that all environmental measures are properly implemented and that auditable records are kept of this having been done.	OBS	MB	Noted. An ECoW would be appointed by the contractor and would be a full-time member of site staff. This is a requirement of the ECI contract.		
1b	CO (GC)	The comments set out below are provided on behalf of the Planning and Environment Service. Regulatory Department, Gwynedd Council and I confirm that the service is in agreement with the Specialist Environmental Topics that are to be included as part of the Environmental Statement. The comments below provide further suggestions as follows:	C	MB	Noted.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
2b	CO (GC)	Perhaps the documents listed in 1.6.13 'Consideration of other policies and plans' should also make reference to the adopted Supplementary Planning Guidance (as relevant) and recent work carried out by Gillespies for the Isle of Anglesey, Gwynedd and Snowdonia National Park relating to 'Landscape Sensitivity and Capacity Assessment – Final Report' issued in March 2014. The 'Landscape Sensitivity and Capacity Assessment' was commissioned in order to provide evidence to support the policies of the Joint Local Development Plan and as such it is a public document.	C	MB / LJ	Noted. Relevant Supplementary Planning Guidance will be reviewed and reference made where applicable. Gillespies work for the Isle of Anglesey, Gwynedd and Snowdonia National Park relating to 'Landscape Sensitivity and Capacity Assessment will be reviewed as part of the landscape assessment.		
3b	CO (GC)	Section 5.3 of the report relates to 'Cultural Heritage' and I would advise that if the scheme is likely to affect listed buildings that you should also be consulting with the Council's Conservation Officer as the local planning authority has the primary responsibility for such buildings (and conservation areas), and Cadw supports them in fulfilling that role.	C	AFP	Noted. Gwynedd Council's Conservation Officer will be consulted as part of the process.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
4b	CO (GC)	Section 5.4 of the report relates to 'Landscape' and I would advised that the study referred to above carried out by Gillespies for the Isle of Anglesey, Gwynedd and Snowdonia National Park – relating to 'Landscape Sensitivity and Capacity Assessment – Final Report', March 2014 may also be of use.	C	PMc	This report will be referred to in the landscape chapter.		
5b	CO (GC)	Section 5.10 of the report relates to 'Community and Private Assets'. Having looked at this section I have been unable to find any reference to public rights of way/public footpaths which I would assume to be 'community assets'. As such and unless this has been dealt with elsewhere in the report, the effects, or potential effects of the scheme on public rights of way/public footpaths should be adequately assessed and mitigated appropriately as part of the scheme in order to protect such community assets.	C	MB	The assessment of impacts to public rights of way will be addressed in a separate chapter of the ES 'Effects on all Travellers'. This will assess the impacts on affected public rights of way during the construction and operational phases of the scheme, before and after the implementation of mitigation.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
6b	CO (GC)	Section 5.10 touches on the effect of the scheme on the amenities of existing land uses such as private dwellings and community uses. However, I would suggest that a greater emphasis is placed on the evaluation of 'amenity' in terms of the potential effect on private property, particularly residential amenities and property used by the community. The scope to provide suitable mitigation should be thoroughly assessed.	C	MB	The assessment of community and private assets follows guidance in the Design Manual for Roads and Bridges, volume 11. Various other assessment of the effects on different aspects of 'amenity' will be included elsewhere in the ES. For example the 'effects on all travellers' will assess the impact on community severance. The landscape assessment will deal with the visual impacts on residential areas and community receptors. Amenity in terms of noise and air quality impacts will also be assessed for residential areas and community facilities. Suitable mitigation will be developed as part of the EIA process and assessments of impacts with and without mitigation will be provided.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris

Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
1c	JJ (NMWTRA)	1.2.1 Location of scheme – description of locations has been muddled up.	C	MB	Noted. This will be corrected.		
2c	JJ (NMWTRA)	**5.4 Landscape** 5.4.38 Mitigation Measures. Use of sympathetic materials to prevent urbanised feel of the landscape eg using low visual impact kerbing.	C	PMc	Noted		
3c	JJ (NMWTRA)	Use of vernacular boundary forms. Please note the new publications “Clawdd Construction” and “Technical Specifications for Welsh Cloddiau” from the Dry Stone Walling Association Technical (drawn up in conjunction with North Wales Trunk Road Agency to help improve standards for traditional boundaries).	C	PMc	Noted, although this will be in response to a detailed assessment of the study area, in which cloddiau are not typical.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris

Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
4c	JJ (NMWTRA)	Need to look at opportunities for creating wildflower rich grasslands	C	PMc	Noted. Opportunities will be investigated. The principle will be to provide species rich grassland wherever appropriate.		
5c	JJ (NMWTRA)	**5.5 Nature Conservation** 5.5.2 and 5.5.59 Other mobile species where an extended radius needs to be considered include otter (25Km) and Marsh Fritillary (10Km??) (possible at Llanwnda end of scheme?)	C	SS	The desk study will include NBN searches for species beyond that requested within the Cofnod records search, assessments will also be made within the ES of connectivity to the wider area from a habitats and species point of view		
6c	JJ (NMWTRA)	5.5.4 Afon Gwyrfai a Llyn Cwellyn SAC – otters are a feature of this SAC and this needs to be acknowledged as it has been under 5.5.5 and 5.5.6	C	SS	Noted. These will be acknowledged.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris

Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
7c	JJ (NMWTRA)	5.5.6 Pen Llyn a'r Sarnau SAC - Otters are a feature, although far away need to consider landscape scale links to Afon Gwyrfai a Llyn Cwellyn SAC (and also to the Afon Menai a Bae Conwy SAC even though otters aren't on citation)	C	SS	Noted. Otters from Pen Llyn a'r Sarnau will be considered.		
8c	JJ (NMWTRA)	5.5.7 spelling – Waunfawr	C	SS	Noted. Correction will be made.		
9c	JJ (NMWTRA)	5.5.9 There have been records of Marsh tit possibly breeding in the scrub area on the south side of the Caernarfon brick works. This is a significant record both locally and nationally. The Marsh tit is a UK BAP species, s42 species and also on the "Red list" of Bird species of conservation concern, also the European status of this species is no longer considered 'secure'.	C	SS	Noted. This will be borne in mind when undertaking the breeding bird surveys.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
10c	JJ (NMWTRA)	5.5.60 Need to recognise s42 and BAP habitats	C	SS	Noted – will ensure their inclusion within the ES		
11c	JJ (NMWTRA)	5.5.66 Surveys into October may help identify movements around mating and hibernation times. The 13 survey sites proposed seems insufficient considering the number of field boundary features that will be severed. Also is it worth looking for bat casualties on existing known crossings of existing road? (then possible to demonstrate an improvement??)	C	SS	The surveys have been designed in consultation with NRW and to ensure consistency with previous surveys undertaken in 2009 and 2014. NRW have agreed with our proposed bat survey approach including the timing of surveys, survey effort and survey locations. A landscape scale approach is being taken with regard to bats which will include a review of habitat and flight line connectivity and ways to maintain and improved this, ad hoc observations will be recorded throughout all surveys including any road casualties.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
12c	JJ (NMWTRA)	5.5.84 otter surveys – "Suitable locations" -need to look at wetland, marshy or rough grassland, ditch and pond habitats in vicinity and how otters may be travelling to these especially in spring when amphibians spawning. Also look at areas of scrub or dense vegetation such as Japanese knotweed as resting up or potential breeding sites. Many otters deaths in N Wales are found on roads well away from watercourses as they frequently travel across country to suitable habitats and also to link up to other watercourse catchment areas and Afon Menai.	C	SS	Noted – during the habitat survey observations and assessment will made as to the habitat value for otters as well as recording signs of otter activity. The ES will assess potential impacts on otters using both terrestrial and aquatic habitats and ensure connectivity between them are maintained/improved		
13c	JJ (NMWTRA)	5.5.84 Water voles may still be present as no systematic surveys have been carried out in the area since that done back in 1999 (coordinated by myself when I worked for Gwynedd Council at time)	C	SS	Surveys are being included within the programme for this year along affected watercourses		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
14c	JJ (NMWTRA)	5.5.86 Barn owl. Need to find if breeding sites close by as they are likely to be liable to casualties if road within 2km (or more). Also look at putting alternative nest site opportunities if there is a potential issue.	C	SS	Noted – the bat activity surveys will provide opportunity to identify barn owl activity on site and the habitat survey will highlight potential breeding sites		
15c	JJ (NMWTRA)	5.5.87- 90 Need to consider reptiles and amphibians and the implications of drainage detailing, ie amphibian-friendly gullies and “escape routes” and kerbing etc.	C	SS	Noted. These will be considered		
16c	JJ (NMWTRA)	5.5.93 Look at early control of invasive species such as Japanese knotweed and also where such species cross boundaries need to eradicate complete “extent of clump” – to this end may need to purchase land or enter into agreements with adjacent landowners to make this possible.	C	PMc	Noted. Early treatment of Japanese Knotweed will be investigated		
17c	JJ (NMWTRA)	Need to consider trees and the importance of individual trees and also their protection according to BS5837.	C	PMc / SS	Noted. Tree protection would be considered as part of the CEMP in accordance with BS5837.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
18c	JJ (NMWTRA)	Need to consider lower plants and possible lichen/bryophyte interest on trees and stones etc.	C	SS	Noted. These will be considered during habitat surveys and record searches. Note that consultation, record searches and habitat assessments during the Stage 2 study indicated that specific surveys for lichens and bryophyte would not be required.		
19c	JJ (NMWTRA)	Need to look for opportunities to create wildflower-rich grasslands and look at low-fertility soils with virtually no top-soil.	C	PMc	Noted. Opportunities will be investigated. The principle will be to provide species rich grassland wherever appropriate.		
20c	JJ (NMWTRA)	Need to look at sources of native grassland seed, potential donor sites and arrange for local seed harvesting	C	PMc / SS	Noted, this will be investigated.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
21c	JJ (NMWTRA)	Need to look at soil types present, full analysis and also a soil management plan.	C	PMc / MB	Noted. Soil sampling and analysis will be conducted as part of the agricultural assessment. Soil management strategy will be developed with respect to the landscape mitigation.		
1d	JE	Thank you for consulting us on the above scoping report. The document circulated for comment is marked as a draft and pre-dates the February ELG meeting. If there is a final version, please could this be circulated as soon as possible?	C	MB	The scoping report will be re-drafted following comments received by the SEBs and WG. This can be made available.		
2d	JE	The accompanying constraints maps provide a useful overview but omit three important areas: the Caernarfon Castle and Town Walls World Heritage Site (from the key plan); shading denoting Registered Historic Parks and Gardens; and Conservation Areas. A couple of corrections to terminology are needed: in the list of abbreviations, 'HER' stands for 'Historic Environment Record' and the list should also include 'WHS – World Heritage Site'.	C	MB	Noted: these will be revised.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
3d	JE	As noted in my interim email response, I would advise that documents should refer to 'Gwynedd Archaeological Planning Service' rather than 'the Senior Planning Archaeologist at Gwynedd Archaeological Trust'. This is in the first instance for the avoidance of confusion with the commercial wing of the Gwynedd Archaeological Trust and secondly because it is the service, rather than a specific individual, who is the curator/consultee.	C	MB	Noted 'Gwynedd Archaeological Planning Service' will be referred to in the scoping report and future documents.		
4d	JE	I have a number of concerns about the proposed scope of archaeological assessment and evaluation. As a general note, I would highlight that the work will need to include all ancillary areas, offline works, and areas of landscaping and ecological mitigation. It is appreciated that these locations will be agreed as the scheme design evolves, and it is mentioned at this stage to ensure potential archaeological issues and their wider consequences are not overlooked.	C	AFP	All ancillary areas, offline works, and areas of landscaping and ecological mitigation will be included within the assessment.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
5d	JE	The proposed study area of a 200m radius along the length (approx. 500m total width) is relatively narrow, and a corridor of 1km width centred on the provisional route centreline is more appropriate in order to gain representative HER data, including results of recent work. As the scoping report notes, this is a rural area which is likely to have a high potential for as yet undiscovered sites, so to use a narrow survey corridor that steers between known sites (either intentionally or by coincidence of sites with other constraints such as settlements) is self-defeating. A narrower study area is adequate for other sources (aerial photographs, historic maps etc); though I would note that Bangor University archives and the Welsh Highland Railway may hold relevant material additional to that held by the repositories listed in the scoping report.	C	AFP	The potential risks of taking too narrow a snapshot along the route alignment are recognised, though this has to be balanced against an assessment of the scheme using an unwieldy – and partially irrelevant – baseline. Some winnowing of data/scoping out may need to be applied for the actual impact assessment. The possibility that Bangor University and Welsh Highland Railway may hold information will be investigated. A broader study area, based on a formal data search of 500m from design centreline, will be adopted.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
6d	JE	Since the scheme does not fall within a Registered Historic Landscape, I would agree that ASIDOHL2 would not be constructive. However, the scheme is relatively close to two Registered Historic Landscapes, Dinorwic to the north and east and Dyffryn Nantlle to the south-east. The assessment should consider impacts on the setting of these landscapes, since these include elevated areas that will overlook the scheme.	C	AFP	Noted. The assessment will consider impacts on the setting of these landscapes.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
7d	JE	Inland-coastal links and associations with the slate industry, with reference to the World Heritage Site bid, should also be considered. It is advised that assessment of visual impacts upon the setting of Registered Historic Landscapes and statutorily protected sites should make use of the landscape and visual impact data, in particular ZTV/ZVI plans, rather than using an arbitrary distance from the scheme (as suggested under 5.3.22). Recognising both that this may entail a significant number of sites and that impacts upon setting are not always visual, the assessment will need to define the setting of a given site or area and establish its contribution to the overall significance of the site in order to eliminate places from assessment and determine impact, in accordance with current guidance.	C	AFP	The assessment will consider potential indirect impacts of the scheme (both physical and non-physical, along the broad lines set out by ASIDOHL2 Stage 3). This will include issues such as severance and fragmentation, which would apply to linear features or extensive land parcels. The EIA will consider these linkages and associations.		
8d	JE	I am happy with the proposed scope of geophysical survey and look forward to receiving a detailed specification for this, together with details of the contractor undertaking the work, in the near future.	OBS	AFP	Noted. The specification of the geophysical survey will be discussed with GAPS before the survey commences.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

9d	JE	The scope of trial trenching has been significantly underestimated. Taking a median scheme width of 65m (based on 30m-100m working width), even a 1% sample would amount to over 100 trenches (each of 2m x 30m). Trenches will need to investigate seemingly 'blank' areas as well as potential sites identified during the course of assessment and survey, and even with high quality geophysics results, a substantially higher proportion should be expected.	C	AFP	The scope was modelled on the strategy adopted for A483/489 Newtown, as agreed with CPAT. Here, evaluation trenches focused on known archaeology; blank areas were not investigated. We of course recognise that the current dataset (developed for Stage 2) is inadequate, and that geophysics does not necessarily reveal all archaeological features that are present. The recent discussions with GAT/Cadw indicate that this has been the case for other surveys in the district. We would prefer to reserve further comment on this issue until a full suite of desk-based data has been assembled, and preliminary geophysics results are obtained. Further discussion with GAPS will be undertaken.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
10d	JE	With this in mind, as mentioned in the ELG meetings, it is imperative given the very short timeframe for this scheme that archaeological work is commenced as an urgent priority. Not only will results of archaeological fieldwork need to be included in the environmental statement, but moreover there is limited scope for alterations to avoid significant sites following fixing of the land take corridor. The time and cost implications of discovery of a significant site (whether this is spot-scheduled by Cadw or whether excavation is required) are considerable.	C	AFP	The project team are aware of the need to progress the archaeological investigations as quickly as is practicable. During Key Stage 3, field work will be restricted to evaluation – i.e. satisfactorily establishing extent, date, form and condition of buried features. Should a site be discovered that is considered schedulable, this will clearly need to be discussed as a matter of priority within Key Stage 3. Any excavation required would be undertaken at Key Stage 6 – i.e. as mitigation: post-consent but prior to construction.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris

Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
11d	JE	I am generally concerned by the inclusion of the impacts section (5.3.26-5.3.31) at this stage as this prejudges potential impacts before the scheme design has been finalised or the research informing assessment has been undertaken. It is presumed that the basis for this is the Stage 2 study previously undertaken by Pearson Archaeology (2009) as the HER has had no recent enquiry and we have had no direct consultation. We do not appear to have received the Stage 2 study and so are unable to comment on its adequacy, though it will now naturally be out of date.	C	AFP	The Stage 2 Report remains the valid document for the preceding options appraisal. The discussion of impacts within the Scoping Report was intended as indicative only. There is no pre-judging of impacts, beyond those that evidently carry through from the Stage 2 assessment. The scoping report recognises the inadequacy of the current baseline – both explicitly (section 5.2.30) and implicitly in the detailed data-gathering that it sets out for the EIA.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
12d	JE	Similarly, it is somewhat previous to outline a mitigation strategy at this stage. I would note that our preference is increasingly for archaeological matters to be addressed as far as possible before construction (by redesign, prior excavation, and/or strip, map and record progressing immediately ahead of construction works), rather than as a watching brief, because of the risks to all interests once construction is under way.	C	AFP	The Scoping Report presents a mitigation strategy that is not yet defined, and where all options (including for re-design and preservation in situ) remain open. The preference for early-stage archaeological mitigation is agreed.		
13d	JE	Two further options might be added to the list, namely opportunities for enhancement or increased protection of sites and/or use of landscaping measures; and palaeoenvironmental sampling of any suitable deposits, if this does not form part of the evaluation strategy.	C	AFP	Noted. These options will be considered.		
14d	JE	I would also draw your attention to the post-excavation programme, which will form a large part of the mitigation strategy and may well continue after the opening of the bypass.	C	AFP	Post-excavation will be included as an integral part of any fieldwork undertaken for this project.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
15d	JE	At the ELG meeting I raised concerns about the potential implications of the ground investigations due to commence next week and requested details of the proposed works. The scoping document mentions a geotechnical watching brief (5.3.20) but I have not received any details, nor have either Ashley Batten at Cadw or I had any consultation as to whether there are any archaeological constraints or mitigation requirements for the works. Please could this information be forwarded as a matter of urgency in order that any necessary measures can be taken to address potential archaeological impact?	C	AFP	This matter has been addressed in the interim between GAPS' comments and this response. Certain trial pits were watched, and data obtained for others of interest. The remaining GI programme has proceeded without archaeological supervision, though all changes to the design/location of the GI are being referred to AP. The entire dataset from the GI will be available for the use of the cultural heritage assessment.		
16d	JE	In addition, I understood that a project structure chart and timescale were to be circulated for information. I would be obliged if this could be done as soon as possible to ease communication and partnership working throughout the project.	C	MB	Noted. This will be provided		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris

Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
1e	AB	Section 5.3.22 states that setting impacts will only be considered within 360m of the scheme centreline. As highlighted in the comments from GAPS (dated 13th March 2015) this arbitrary distance would not be considered appropriate and any such assessment must be informed by ZTV or similar. This is of particular importance in consideration of more distant upland monuments which might overlook the scheme but also in relation to the World Heritage Site at Caernarfon where any effect on the views from Caernarfon Castle would need special consideration (views from the towers and other elevated positions need to be considered).	C	AFP	The ZTV will be used to define a wider envelope for the assessment of impacts/changes on the setting of key/high value heritage sites. Photomontages can be generated for key viewpoints, and there is potential opportunity to include some of these within the LVA. The visual assessment will address a wider envelope than that specified in the scoping report. Cadw will be consulted on potential longer-distance viewpoints.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
2e	AB	Section 5.3.25 states that indirect impacts will be considered either 'indirect physical' or 'indirect visual'. A more nuanced understanding of setting may be required in assessing the potential impacts on Scheduled Ancient Monuments where other issues such as noise may have an effect even where the monument is not necessarily inter-visible with the bypass.	C	AFP	Agreed. The assessment will consider indirect 'non-physical' aspects of setting.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris

Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
3e	AB	Section 5.3.31 identifies that there is likely to be a significant effect on the settings of numerous scheduled ancient monuments along the alignment of the scheme, most significantly on the setting of Caerlan Tibot Defended Enclosure CN400. This raises **significant concerns** for Cadw although we would welcome discussion in relation to realignment / design options around Caerlan Tibot as mentioned in section 3.2.1 of the scoping report.	C	AFP	A site meeting at Caerlan Tibot was held with Cadw on 10 April 2015. The impacts on this site will be investigated further, with attention paid to the exact design of the scheme at this location, including the extent of lighting and screening. The status/usage of the existing road at this point also needs to be established. Further research, and subsequent discussion with Cadw, is necessary on this subject.		

Schedule of Comments and Responses

Contractor/Designer	JV Team / PB / TACP	**Employers Agent**	Ramboll / EC Harris
Document Title:	**Environmental Scoping Report**		
Document ref No	3513874-PB-XX-XX-RP-EN-00001		
Date comments received:	17/03/2015 (NRW) 26/03/2015 (GC) 26/03/2015 (NMWTRA) 13/03/2015 (GAT) 30/03/2015 (Cadw)	**Reviewer:** Dr David Hatcher (DH) – NRW Cara Owen (CO) – GC Jill Jackson (JJ) – NMWTRA Jenny Emmet (JE) – GAT Ashely Batten (AB) - Cadw	**Team respondents** Lee Jones (LJ) – TACP Max Burrell (MB) – TACP Sam Shove (SS) – TACP Pete McComiskey – TACP Claire Storer (CS) – WSP/PB Martin Lucass (ML) – WSP/PB Kevin Power (KP) – WSP/PB Peter Tylor (PT) – JV Team Andy Pearson (AFP) – Pearson Archaeology
Date comments returned:	27/03/2015 (NRW) 31/03/2015 (GC) 16/04/2015 (NMWTRA) 16/04/2015 (GAT) 16/04/2015 (Cadw)		

Comment Ref:	Initial of reviewer	Comments	Comments status	Initial of respondent	Response to Comments	Further Actions	Actionee
4e	AB	The mitigation as set out in 5.3.33 identifies only standard archaeological mitigation options comprising either essentially preservation in situ or preservation by record. Given the potential indirect effects on a number of designated monuments it should be appropriate in this case for other options to be considered alongside the standard archaeological processes. These could include landscaping, planting, monument management, access, interpretation, or other approaches to try to ameliorate any unavoidable adverse effects on designated sites or monuments. These issues should be explored within the EIA alongside the archaeological mitigation strategy and in conjunction with the realignment / design options discussed above.	C	AFP	These possibilities will be explored during the compilation of the EIA. However, the practicality of carrying out works outside the development area – i.e. on land not owned by WG – is a potential obstacle to at least some of the suggested approaches. The draft EIA will set out the proposed mitigation strategy. Discussion between the JV team and Cadw will be necessary to establish the practicality of any non-standard options that are suggested outside the land owned by WG.		

Appendix A.3 – ELG and NRW meeting minutes

MINUTES

Date: 24th May 2016

Venue: NRW Offices, Penrhosgarnedd, Bangor.

Meeting title: A487 Caernarfon and Bontnewydd Bypass, NRW Meeting to discuss ES/SIAA

Contract No: 3513874A-HHC

Purpose: To discuss way forward with Pont Afon Rhyd and LHB issues in ES/SIAA.

Present:

Peris Jones (PJ)	Welsh Government
Sas Fernando (SF)	Welsh Government
Len Wyatt (LW)	Welsh Government (by telephone)
Theresa Kudelska (TK)	NRW
Peter Evans (PE)	NRW
Phil Oliver (PO)	NRW
Mike Jones (MJ)	BBJB JV
Peter McComiskey (PM)	TACP
Sam Shove (SS)	TACP
Neil Garton Jones (NGJ)	WSP|PB
Russell Bennett (RB)	WSP|PB
Peter Fox (PF)	For TACP
David Williams (DW)	For TACP
Jeff Turner (JT)	Ramboll

Apologies:

Item.	**Action and date required**

1. Introductions

PJ introduced the team and thanked NRW for their time and for arranging the meeting.

2. Purpose of the Meeting

PJ set out the objectives of the meeting.

3. Explanation of David Wells' and Peter Fox's roles on the project

PJ introduced David Wells and Dr Peter Fox to the meeting and explained that their role thus far had been to provide an independent review of the specific work to date on bats and S102 Fisheries/Water Framework Directive. It was confirmed that both would be part of the project team moving forward.

Item.	Action and date required

4. Bat Issues

i. Current situation

SS gave the background to the bats issues and outline the current proposals with respect to both survey activity and mitigation.

ii. Surveys to date

SS went through the results of the surveys currently being carried out for May 2016.

It was agreed that SS would send the May survey data to NRW post meeting. *SS - ASAP*

DW explained that the results of previous years 'surveys and those to date in May 2016 are quite difficult to interpret and are indicating foraging behaviour rather than definite commuting flight paths.

PE asked for details of survey results each month. It was agreed to issue the summary results to NRW each month with a brief analysis. It was also agreed to hold a call if the results show any new findings or different behaviour to that currently being recorded. *SS – As required*

PE mentioned the need for details of all bat species. DW noted this would require significant analysis of the static recorder findings. Discussion was had on what information NRW want to receive and it was agreed that only species identity was initially required but that all data was retained and held for future interrogation if needed.

iii. Mitigation Proposals

SS set out background to the mitigation strategy that is based around the scattered bat activity recorded and that the general principals were to provide general permeability across the bypass with associated planting to promote movement of bats along linear features to the crossing points provided.

PM stated the landscaping planting design had been cut back in the scheme to increase the distance that bats would need to cross the bypass hence making this less attractive and reducing the risk of bat mortalities.

PE stated manipulating LHB to divert is more difficult and whilst they can learn to do this we are 'asking a lot of the bats to change behaviours' and there are 'long gaps' between crossing points.

DW asked PE if he agreed that we are looking at foraging bats and not commuting routes? The difference between dealing with foraging and commuting bats was discussed and whether we should apply the same principles for mitigation? PE stated that he did not feel there was a difference to be made and that the bats would forage whilst commuting from one foraging area to another and that in his view we should not differentiate when it comes to mitigating the effect of the scheme.

PE considers the risk is equal for both foraging and commuting. He believed

Item.	Action and date required

that there are some areas where we could add further crossing points and also, critically, that there are gaps in the survey data collected to date and that this leads NRW to being uncertain that all potential crossing points have been identified.

PE explained that he couldn't provide a definitive response as to whether the level of culvert crossing points being proposed is an appropriate level of mitigation/permeability of the bypass as the survey data to date does not provide enough information. How to resolve this was discussed however PE accepts you cannot survey all hedgerows but does consider that many more should be surveyed to give him confidence in the mitigation approach of providing general permeability.

iv. Proposed Surveys

PM asked whether there is agreed principles or quality threshold for when hedgerows are deemed suitable for survey.

PE stated that the surveys so far this year are an improvement and should continue. He suggested that more data could be gathered more efficiently by making better use of static detectors at hedgerow locations not previously surveyed (no need for static and people on all transects once it is established what the baseline data is). PE feels that NRW are being put in a difficult position with regards to making a judgement on the impacts of the scheme as in their view the survey data is not sufficient.

PJ set out revised timetable for project stating that Orders are now to be published July/August 2016 leading to a PLI early 2017 and start of construction on site late 2017. This provides us with the opportunity to gather survey data for two seasons before we start construction.

DW asked whether there are any features which NRW advise that we should focus on when choosing additional hedges to survey. What are the triggers?

PE stated that we should aim to increase permeability where you can regardless of survey results.

There was a lengthy discussion around how to approach the survey programme for 2016/2017 in order to gather enough information to satisfy NRW's requirements without having to survey all hedges on the scheme.

It was agreed that the best approach was to take the discussion to the site walkover where the most suitable locations for additional transect could be identified, debated and agreed on site.

PE re-iterated his previous view that the Quarry area is a good foraging area for bats (best on the scheme) and requires an additional crossing point in his opinion.

PM said that the survey data shows that the bats are on the edge of the woodland rather the Quarry and that this area is already covered by crossing points.

Item.	Action and date required

v. General discussion on bats

PM explained that the proposed mitigation is based on evidence/data from existing survey findings. He noted that the team want to agree the way forward with surveys for this season so that the data gathered can be used to further inform the mitigation proposals.

PE's view was that whatever the findings of further surveys the scheme will not change if we don't change it now. PE doesn't accept there is flexibility to change at a later date i.e. post publication of orders. Therefore, regardless of what any future survey results show PE wants to reduce the gaps in connectivity across the bypass i.e. more culverts.

DW asked whether NRW are comfortable with some diverting of LHB to crossing points where planting is continuous. PE tended to agree but said it was dependent on a number of decision factors such as bat numbers, type of planting, cost effectiveness etc. PM added that as LHB will be everywhere along the scheme it must be accepted that planting will provide connectivity between crossing points.

PO asked how is the project team future-proofing the scheme i.e. adding crossing points and other measures to deal with potential change/increase in LHB numbers or other species being present in the future? PM explained that this can be difficult when a project goes through the CPO process to acquire land for the scheme as the justification for including land in the CPO must be evidence based i.e. based on survey data. Therefore, due to the low numbers being recorded it would be difficult to justify buying land for essential mitigation where it cannot be proved by evidence that it is required.

DW added that 'future proofing' had so many variables to consider such as climate change etc and therefore would be difficult to forecast with enough evidence to satisfy challenge at a PLI.

PO brought the discussion back to reducing the gaps and how an approach of general permeability required more culverts regardless of the current evidence as we cannot be certain what the LHB behaviour and numbers will be in the future. NRW feel very strongly about future proofing and making sure we have enough permeability across the scheme.

DW asked if there is a view from NRW as to the maximum gap to aim for so that we can have a consensus on what we are trying to achieve. PM stated that mitigating for foraging bats is difficult and is not something that has been done on previous schemes. PE/PM discussed the hierarchy of mitigation measures that can be provided where no specific commuter routes with large numbers are present. It was agreed that attempting to provide crossing points at all the 90 hedgerows severed by the bypass is unreasonable but PE believed that we could do more for 'future-proofing' and reducing the gaps by providing crossing points at locations where hedgerows can be identified as having a high potential for being features that bats would follow.

PE suggested a separate forum to go through the details and potentially review all 90 hedgerows for the purposes of agreeing the better ones and influence the surveys going forward. PE/JT best approach would be to keep the baseline and

Item.	Action and date required

identify the better hedges, potential crossing points and additional surveys during the site visit.

The use of static detectors initially on hedges that haven't been surveyed was discussed. This would enable us to 'scope' new transects to decide if people surveys are needed. PE agreed this would be a good way forward.

PO noted again that we should be doing more to mitigate for other species (future proofing and those potentially present now). Section 42 list of species was mentioned as needing to be assessed for. The long gaps in crossing points was again raised in terms of connectivity for other species such as otters. It was noted that the northern habitat is less favourable and therefore the reduced number of crossings on this section was more acceptable.

DW asked whether future proofing a new concept for NRW as he had not come across it on other projects. PE said it was something they had always considered and aspired to and with new legislation such as the Future Generations Act and the Environment (Wales) Act it is becoming a higher priority.

PE asked whether green verges could be considered on overbridges with ideally hedgerows continuing over the bridges. PM mentioned that there would be engineering issues to consider but the team committed to carry out an assessment of the potential for providing green verges.

It was agreed that the site visit would be used to help validate the existing/prioritise the new survey locations.

The addition of culverts to minimise gaps in connectivity in order to future proof the project rather than as a direct result of data/eveidence needs to be considered by the project team. The culverts could not potentially be justified as essential mitigation so the 'defence' at PLI for the CPO would need to be based on a different basis related potentially to new legislation, etc.

5. Structure S102/Afon Rhyd

NGJ set out the review of the highway alignment and how the scheme has been defined to date. In particular, the impacts on the Afon Rhyd/Y Parc. NGJ also outlined the various structure solutions that have been considered as an alternative to the culvert solution.

PE and PO are uncomfortable with the culvert solution with the fisheries impact from the loss of existing river bed. PM explained the landscape impact associated with other more open structures. NGJ noted the increased construction problems with a structure which maintains the existing natural bed e.g. piling operations and the working space required.

PF explained that he was brought in to review the culvert option proposals and that his initial findings was that the scheme design as it was would not be acceptable from a fisheries perspective.

PF noted that the river needs to be passable for all species of fish – salmonoid

Item.	Action and date required

through to lamprey and elvers. Critical flow speeds to be as low as 0.6m/s. (The initial design was 2.0m/s without mitigation). The preference would be baffles rather than louvres as in flow mitigation to provide a fish pass. This solution could provide some sediment build up but a 5 to 10 year spate floods would wash out sediments so careful design consideration is needed to encourage the build up of sediment. PF recommended that a lower culvert invert is constructed with some downstream mitigation to prevent erosion. The upstream 'new' channel needs to be designed with meandering to allow for re naturalisation of the river and to provide fish resting. PF added that large rocks placed to create eddies would be beneficial. The key is constructing the diverted stream right in the first place to enable it to develop into a more natural state with time. The culvert itself should be designed as a fish pass.

PO stated that there is good spawning potential in this area and that he would have liked to see some fish surveys carried out to confirm this given the status of the river.

PO added that this should be considered as a multi-species corridor and the current proposals will not make provision for other species. Future proofing for other species was again mentioned as an aspiration. This could include species not yet native to this area.

The Afon Cadnant needs to be treated similarly to the Rhyd in terms of assessment of impacts.

PO/PE commented that there are alternatives which provide better proposals for all wildlife than culverts. PO added that otter ledges are not preferred and that river 'bank' dry passage are preferred for all species.

PO expressed that the ES doesn't deal with all S42 species. There was a discussion on need for permeability and the ability to get all species to use the culverts, future-proofing allowances for species not yet recorded and whether this approach could be justified in terms of land acquisition via CPO and value for money.

DW's view was that it would be difficult to justify a structure that maintained the natural bank at PLI because it couldn't be demonstrated that the proposed solution was not an appropriate approach to mitigation for the know species i.e. LHB, fish and otters.

PO noted that the issue he had was that there isn't enough information available in the ES for NRW to be satisfied the proposals and mitigation are going to be effective. The mitigation for migrating fish and lost spawning grounds is a key aspect for this structure and will need to be addressed in more detail than currently has been in the ES.

PO raised concern about the lack of Fisheries survey data in the ES. PM explained that the approach had always been to mitigate for all species of fish and eels and that the current proposals would provide this. However the project team were open to discussions about any additional surveys that could be carried out.

Item.	Action and date required

6. Other species/issues not covered above

TK raised the issue of water voles potentially being present at the quarry. SS stated that the surveys carried out did not identify this area as potential habitat. NRW were keen to look again at this area and this should be considered during KS4.

PE noted that there had been badger activity recorded at the top of Quarry. SS replied that no active setts had been found last year. We need to consider whether further surveys are required in KS4. NRW acknowledged the low activity doesn't justify badger fencing and agreed that some areas of otter fencing may help. NRW to pass on their evidence to TACP.

7. Site Visit

Separate notes are to be prepared for the site visit.

DISTRIBUTION: Attendees (plus apologies) and copies to:

Approved by: Russell Bennett Date: 10/6/16

Issued by: Neil Garton Jones Date: 10/6/16

A487 Caernarfon and Bontnewydd Bypass

Meeting Notes

Meeting Title	**Environmental Liaison Group Meeting**	
Date and Time	9th Dec 2015	10.30 – 15.30
Location	Celtic Royal, Caernarfon	
Attendees	Sas Fernando (SF) – Welsh Government Chris Worker (CW) – Welsh Government Len Wyatt (LW) – Welsh Government Mike Jones (MJ) – JV Christina Kelly (CK) – JV Neil Garton-Jones (NGJ) – WSP/PB Richard Perkins (RP) – WSP/PB Claire Storer (CS) – WSP/PB Marc Thomas)MT) – WSP/PB Peter Evans (PE) – NRW Emyr Gareth (EG) – NRW Walter Hanks (WH) – NRW Theresa Kudelska (TK) – NRW Mark Medway (MM) – NRW Max Burrell (MB) – TACP Lee Jones (LJ) – TACP Peter McComiskey (PMc) – TACP Ben Sears (BS) – TACP Samantha Shove (SS) – TACP Jeff Turner (JT) – Ramboll Laura Matthews (LM) – Ramboll Hilary Morgan (HM) – Ramboll/Morgan Henshaw Emily Mielleur (EM) – Gwynedd Council Cara Owen (CO) – Gwynedd Council Dewi Wyn Owen (DWO) – Gwynedd Council Geralllt Jones (GJ) – Gwynedd Council Euron Thomas (ET) – Gwynedd Council Alun Williams (AW) – Gwynedd Council Jenny Emmett (JE) – GAPS Jill Jackson (JJ) – NMWRTA Andy Pearson (AP) – Pearson Archaeology	

No	Contributor	Item	Action
1	MJ	Welcome and introductions – all present introduced themselves and their role.	

No	Contributor	Item	Action
		Purpose of ELG explained – updating progress, opportunity to discuss issues	
2		Description of Scheme	
3		Programme update –draft ES issued for comment, final Issue ES mid Feb, CPO early March, PI early July	
		Start works Dec16/Jan 17	
4	LJ	Explained the process followed to from DMRB to ensure environmental factors inform the scheme design. Agreed to go through draft ES by topic headings.	
5	MT	Air Quality Chapter – Standing in for Bethan J Jones who is lead Air Quality specialist. Delivered slides explaining assessment process and findings to date. Have 9 months survey data to date 3 more months to measure. No major issues affecting communities some potential effects upon biodiversity at Glynllifon- CW queried scale of effects. Noted that further work is required and included in ES. Confirmed that data from Gwynedd Council monitoring included within assessment exercise.	
6	AP	Cultural Heritage – ES now complete so draft document for discussion. A brief summary of relevant factors given. Geophys survey results discussed. Field evaluation to be carried out early in 2016 to inform consideration at PLI .LW raised issue of watching brief being used agreed this would take place in KS6. JE queried programme of trial trenching and access to land. AP noted this and agreed a strict timetable was required	
7	PMc	Landscape – PMc explained assessment process and outcomes in terms of effects and mitigation. LW raised a query on embankment extents Discussion was also made on cutting slopes and potential to leave rock exposed in Plas Menai cutting. Agreed to review at detailed design stage..	**PMc/MJ**
8	SS	Nature Conservation – the assessment process was explained and a number of relevant queries were raised, particularly EM and JJ. It was agreed to both send on information requested and address specific matters at the detailed design stage.	**SS/MJ**
9	MT	Geology and Soils **– assessment explained final outcome dependent on** what is found during construction. Details will be included within the CEMP. MJ explained that more topsoil than originally expected. Former brickworks being looked at for import/export of materials.JJ stressed importance of protecting topsoils during construction. Noted by MJ	**MJ**
1O	MT	Materials – process to date given MT explained some minor discrepancy in amounts' of fill required. Would be addressed prior to publication of draft ES.	
11	RP	**Noise and Vibration – process with use CTRN to assess likely impacts. Over 6000 properties within scheme area of which some 60 adversely affected by the scheme. Mitigation to use low noise road surface.ET noted that Gwynedd Council supported approach to mitigation with some concerns as to scale and mitigation of construction impacts.**	

A487 Caernarfon and Bontnewydd Bypass

MINUTES

Date:	9th July 2015	
Time	10.00am	
Venue:	The Celtic Royal Hotel, Bangor Street, Caernarfon, Gwynedd. LL55 1AY	
Meeting Title:	Environmental Liaison Group	
Contract No:	3513874A-HHC	
Purpose:	Environmental Liaison Group	
Attendees:	Sasanka Fernando (SF)	Welsh Government
	Len Wyatt (LW)	Welsh Government
	Jeff Turner (JT)	Ramboll
	David Hatcher (DH)	NRW
	Iwan Hughes (IH)	NRW
	Chris Worker (CW)	Welsh Government
	Moira Duell (MD)	Gwynedd Council
	Emily Meilleur (EM)	Gwynedd Council
	Elgan Ellis (EE)	Jones Bros.
	Llion Morris (LM)	Balfour Beatty
	Lee Jones (LJ)	TACP (Env. Coordinator)
	Max Burrell (MB)	TACP (ES Coordinator)
	Peter McComiskey (PMc)	TACP (Landscape Architect)
	Jean Hamilton (JH)	TACP (Ecologist)
	Mike Jones (MJ)	Project Manager Joint Venture
	Sharon Carr (SC)	Design Co-Ordinator WSP/PB
	Mark Medway (MM)	NRW
	Walter Hanks (WH)	NRW
	Andrew Pearson (AP)	Pearson Archaeology
	Jenny Emmett (JE)	GAT
	Iwan Arnold (IA)	Gwynedd Council
	Rhydian Roberts (RR)	Gwynedd Council
Apologies:	Peris Jones	Welsh Government
	Jill Jackson	NMWTRA
Circulation:	Attendees & apologies	

Item	Action and date required

1. WELCOMES AND INTRODUCTIONS

1.1 EE welcomed everyone to the 3rd Environmental Liaison Group (ELG) meeting for the A487 Caernarfon and Bontnewydd Bypass Scheme.

1.2 All attendees introduced themselves and their role within the project.

1.3 LJ confirmed there were no outstanding action items from the previous meeting.

2. UPDATE ON SCHEME DESIGN

2.1 SC presented a summary of the current scheme proposals including specific locations that were discussed in greater detail:

- Gwyrfai Viaduct (S106) VE option – including flood modelling
- Seiont Viaduct (S112) VE option – including north side abutment access and haul road requirement
- Lighting & Bethel Road Junction
- Structures S116 / S118
- Plas Menai Cutting & Crug Farm link to Plas Menai Roundabout

2.2 *Gwyrfai Viaduct (S106) VE Option*

2.2.1 The Gwyrfai Viaduct VE option would result in more embankment being in the floodplain, but with culverts within the embankment to mitigate potential flooding impact. Flood modelling for the 1 in 1000 year event has shown this would result in a change in flood depth, but not in frequency.

2.2.2 CW and EM raised concerns regarding the potential increased impact on protected species associated with this option, such as impacts on otter.

2.2.3 IH stated it was a big concern extending the embankment into the floodplain and that NRW probably could not support the proposal. Other flood modelling scenarios would need to be explored such as extent of flooding with culverts blocked etc.

2.2.4 EE and SC confirmed that options such as the Gwyrfai were being explored as part of a value engineering exercise.

2.3 *Seiont Viaduct (S112) VE Option*

2.3.1 The Seiont Viaduct VE option would also result in more embankment on the southern side of the river, but would be outside of the floodplain. NRW had been consulted and comments received and addressed.

2.3.2 Similar concerns regarding protected species were raised in relation to the Seiont option. It was also noted that Japanese Knotweed was present in this area.

2.3.3 PMc noted that extension of embankments provides more opportunity to mitigate landscape and visual impacts.

Item		Action and date required
2.3.4	MD stated that Giant Hogweed was known to be present on the Glan Gwna Holiday Park.	
2.4	*Lighting & Bethel Road Junction*	
2.4.1	The lighting proposals for the scheme include fully lit Goat and Plas Menai Roundabouts, including the bypass approaches. At Meifod Roundabout, the roundabout would be lit as a 'ring of light' and the existing A487 arms to the east and west would also be lit, but not the bypass arms. Similarly at Cibyn Roundabout, the roundabout would be a 'ring of light' and the existing A4086 to Cibyn Industrial Estate would be lit, but not the bypass arms.	
2.4.2	The current light proposed is LED with full cut-off beams. Minimising lighting along the Scheme would be of benefit to wildlife, particularly light intolerant species such as Lesser horseshoe bat.	
2.4.3	SC explained that the existing roundabout on the B4366 Bethel Road will be removed and replaced with an unlit crossroads junction to the east of the bypass. The existing roundabout is lit, and Gwynedd Council have expressed a desire for the roundabout and lighting to be replicated at the new junction location. No concerns were raised regarding the requested lighting in this location, since it would still be an improvement on the existing situation.	
2.5	*Structures S116 / S118*	
2.5.1	There is a need to divert an existing stream north through a closed culvert between Ch8870 and Ch9050 in order to bypass the proposed cutting. The 600mm dia culvert (S116) would pass under the new side road and daylight in the gap between the two roads. The stream would then re-enter another 600mm dia culvert (S118) to pass underneath the bypass and then run adjacent to the bypass before reconnecting with the existing streamcourse to the west of the bypass.	
2.5.2	An alternative proposal of just culverting the crossings beneath the two roads and providing an open streamcourse adjacent to the bypass running northwards was also discussed. Similarly an alternative to sever the existing streamcourse and divert flows to the Cadnant tributary were initially considered, but rejected following discussion with NRW due to flooding concerns in Caernarfon.	
2.5.3	A number of concerns were raised regarding the length of proposed closed culverts proposed, particularly in relation to impacts on European eel (possible impacts on the Eel Regulations), trout and otters.	
2.5.4	RR to establish Gwynedd Council's culvert policy.	RR
2.5.5	SC commented that the open watercourse solution would raise health and safety concerns regarding the construction and maintenance adjacent to the Plas Menai Cutting. AP also advised that the excavation of a wide ditch is this location would raise archaeological risks.	

Item	Action and date required

2.6 *Plas Menai Cutting & Crug Farm link to Plas Menai Roundabout*

2.6.1 As a result of the findings of the ground investigation, the previously proposed benched rock cut at the scheme's northern end (Plas Menai Cutting) would be amended to a single 1 in 2.5 slope, due to the absence of competent rock throughout the cutting.

2.6.2 SC also explained that we had been instructed to reconnect the link from Crug Farm to the Plas Menai Roundabout, which would impact on the existing Bryn Covert woodland.

2.7 *General comments*

2.7.1 DH requested that NRW be consulted on all proposed design changes.

2.7.2 LJ summarised some of the measures being adopted to mitigate impacts on biodiversity:

- Oversize culverts (1.8m average size)
- Additional bat crossing points
- Culverts with natural stream beds

These are provisionally shown on the Draft EMPs and help form the 'bat landscape' approach to the scheme landscape / mitigation strategy.

3. PROGRAMME

3.1 LJ summarised the current programme:

- Environmental surveys (on-going)
- Publication of draft ES (October 2015)
- Publication of draft Orders and Final ES (February 2016)
- Start of Public Inquiry (July 2016 – if required)
- Inspector's report (September 2016)
- Ministers decision (November 2016)
- Start of construction (December 2016)

4. SURVEY PROGRESS

4.1 JH summarised the ecological surveys to date:

- Great crested newt (GCN) surveys complete. This consisted of Habitat Suitability Index survey of all ponds within 500m of the Scheme. Two ponds found to be 'average or above' and were subject to egg searches, torch light surveys and bottle trap surveys. No GCN found to be present. Palmate and Smooth newt confirmed.
- Hedgerows: The majority surveyed are species poor and frequently managed by flail
- Preliminary bat roost assessment of trees undertaken. Further tree climbing surveys proposed based on results of preliminary assessment.

Item		Action and date required
	• Badger surveys complete – very little activity across the Scheme. Bait marking to determine territories not considered necessary given low activity levels and lack of setts found. • Dormouse habitat potential assessment completed. Majority of areas either sub-optimal or suitable for dispersal only, therefore nest tubes surveys are not being carried out. • Otter and Water Vole surveys completed. No signs of otter found during surveys although their presence is known from previous surveys and record searches. Signs of Water Vole were noted. • Breeding birds surveys completed. Total of 77 species – two Schedule 1, eight are listed as being a species of European Conservation Concern, eight red listed, nineteen amber listed. • Bat activity surveys: First round completed May 2015. 10 no. species recorded across the site. Lesser horseshoe bats recorded at 7 of the 13 transects. July surveys currently underway. Last round of surveys programmed for September 2015.	
4.2	EM noted that Marsh Fritillary Butterflies were known in the local area and should be considered in the assessment. It was confirmed that local biodiversity record searches had been carried out for Marsh Fritillary. Their food plant (Devil's-bit scabious) would be picked up in habitat surveys undertaken.	
4.3	PMc stated that ecological surveys that are taking place have been agreed with the relevant statutory environmental bodies through the EIA scoping process.	
4.4	PMc reported the progress of the landscape and visual assessment. A review of LANDMAP data has taken place. The Scheme's Zone of Visual Influence (ZVI) is currently being developed through digital terrain modelling (obtaining Zone of Theoretical Visibility (ZTV)) and survey work. Draft key viewpoints will be circulated to the relevant statutory environmental bodies for agreement.	PMc
4.5	PMc and LJ presented the draft Environmental Management Plans to the meeting. The plans are currently a 'work in progress' and would be further informed by survey and assessments moving forward. They are undertaken in accordance with the DMRB Volume 10, with plots of land being assigned a landscape 'function' and 'element'.	
4.6	LJ stated that the primary function of the balancing ponds was for flood attenuation prior to discharge into water courses. Biodiversity would not be encouraged through planting.	
4.7	Road drainage would be through grass swales and then into balancing ponds. The swales would perform a water treatment function.	
4.8	IH (NRW) stated that pollution control devices would be required within the highway drainage.	
4.9	EM requested that wildflower planting along the Scheme should utilise seed collected locally. PMc stated the team would seek to do this although not all seeding could be provided in this way due to the volumes required. Seed from local provenance would always be sought where feasible.	

Item		Action and date required
4.10	AP summarised the progress of cultural heritage surveys so far: • Review of historic maps and aerial photographs • Geophysical surveys of the entire route corridor	
4.11	Some of the key known historical features along the site are: • Caerlan Tibot enclosure • Segontium Roman Fort • Bryn-Glas Roman signal station • Caernarfon Castle and Walled Town	
4.12	Evaluation trenching has been agreed in principle. This will: • Inform the EIA • Inform the contractor of potential mitigation measures required and how this may affect the construction programme Under the Highways Act this can only take place with landowner consent.	
4.13	AP to liaise with LM & JE regarding a plan for trenching work.	AP / LM
4.14	JE noted that Cadw were interested in the possibilities of enhancing Caerlan Tibot SAM. The possibility of providing interpretation and improving access to the monument was discussed.	
4.15	Ashley Batten of Cadw requested some long-distance view points from SAMs to be included in the visual impact assessment. PMc to liaise with AB regarding this.	PMc
4.16	Scheme lighting was further discussed. NRW requested that light modelling / lighting assessment should be carried out to inform impacts on light intolerant species such as lesser horseshoe bats. TACP to review options. Need to consider vehicle light in “dark” areas.	TACP
4.17	Consideration should be given to amphibian crossings if necessary. The current scheme proposals do not include gully pots.	
5.	**ANY OTHER BUSINESS**	
5.1	DH requested that the latest layout plans, draft EMPs and ELG presentation are made available to NRW. JV Team to provide.	JV Team
5.2	PMc confirmed that hedgerow translocation would be considered where appropriate.	
5.3	It was confirmed that attenuation ponds would be in place before soil stripping activities.	
5.4	Next meeting date – mid/late October.	

Item		Action and date required
6.	**NOTES FROM POST-MEETING BREAK-OUT GROUPS**	
6.1	MB to forward MD's contact details to the noise assessment team so she can be contacted regarding the noise assessment.	MB
6.2	MD also noted that the locations of many of the private water supplies along the site were unknown.	
6.3	MD confirmed the location of Giant Hogweed at the Glan Gwna Country Holiday Park to JH.	
6.4	CW and EM confirmed the locations of a number of bat roosts along the Scheme to MB and LJ.	

Approved by: Lee Jones Date: 30/07/15

Issued by: Rachel Davies Date: 30/07/15

A487 Caernarfon to Bontnewydd Bypass

MINUTES

Date:	25th February 2015
Time	10.00am
Venue:	The Celtic Royal Hotel, Bangor Street, Caernarfon, Gwynedd. LL55 1AY
Meeting Title:	Environmental Liaison Group
Contract No:	3513874A-HHC
Purpose:	Environmental Liaison Group

Attendees:

Jeff Turner	Ramboll
Chris Worker	WG
Len Wyatt	WG
Sas Fernando	WG
Jill Jackson	NMWTRA
Jenny Emmett	GAT
Iwan Huws	NRW
Dave Hatcher	NRW
Peter Taylor	JV
Lee Jones	TACP
Russell Bennett	PB
Walter Hanks	NRW
Emily Meilleur	Gwynedd Council
Adam Daniel	Gwynedd Council
Llion Morris	JV
Kate Attwood	PB

Item		Action and date required
1.	**INTRODUCTIONS**	
	Jeff Turner gave an introduction to the Contractor's Team and highlighted the background to the scheme. As the Contractor has now been appointed they will be the point of contact going forward. Peter Taylor is the Contractor's Project Manager leading the project. Lee Jones is the Environment Coordinator. Russell Bennett is the Consultants Project Manager. Kate Attwood is the Stakeholder Manager. Lee Jones explained the purpose of the meeting is to give attendees the opportunity to meet the team, share information and contribute to the scheme development. Peter Taylor described the wider team and presented an organisation chart. Action: Peter Taylor to issue the organisation chart within the presentation attached to the minutes of the meeting.	*Click here and press tab for the next item*
2.	**PROGRAMME**	
	Key Stage 3: Preliminary Design and Preparation of Draft Orders and the Environmental Statement – from now until February 2016. Key Stage 4: Statutory Consent Procedures, which is likely to include a Public Local Inquiry – February 2016 – December 2016. Key Stage 6: Detailed Design and Construction – December 2016 until December 2018. Action: Peter Taylor to issue a summary of the programme within the presentation attached to the minutes of the meeting.	
3.	**THE SCHEME**	
	Peter Taylor described the detailed programme dates of the various construction elements including structures, earthworks etc. and outlined the construction methodology. He then presented a fly through of the 'conceptual' and 'developed' designs. (It was noted the 'developed' design was not complete as it was prepared during the tender stage and was still to be evaluated/developed). The scoping report is the next key deliverable for environment. Everyone will have opportunity to comment on that. Len Wyatt raised that the unlike the planning process under the Town and Country Planning Act, the Environmental Statement (ES) is not subject to	

Item	Action and date required

conditions. Therefore the ES Scoping document is a significant activity so consultees need to comment and engage to ensure the ES is robust and complete.

Peter Taylor presented the construction programme for discussion. The construction strategy is to excavate the rock cutting to extract all the premium and general aggregates from the scheme as this will significantly save on import, vehicle movements on local roads and improve sustainability.

The intention is to use the excavated material to construct a haul route for the full length of the scheme and take all construction traffic where possible off the local road network.

Russell Bennett commented that the cutting is not 'over cut' for the purpose of obtaining material. The cutting is designed to ensure that we can design the road entry to Plas Menai roundabout to the required standard.

9 months is EW season for the haul route ad EW. Main structures start August 2016.

4. DISCUSSION

Lee Jones confirmed the Key Stage 2 EIA including confidential appendices and the 2014 Bat Surveys would be issued to all attendees.

Questions were asked about the extent/scale of geophysical survey and culverts.

Jenny Emmett enquired about geophysics surveys. Lee Jones confirmed it would be 100% coverage. There was a discussion about the timing of archaeological trenching in relation to the preparation of the ES. It was noted contractors for this work are in high demand.

Action: Lee Jones to investigate requirements and confirm the timing of the archaeological trenching.

Walter Hanks enquired about any proposals to combine waterways. Peter Taylor confirmed this was not intended and all culverts would have natural inverts set below river bed level to encourage natural bed development.

Ecological mitigation – Has it been considered, e.g. Extra land for planting and compensation areas. LJ confirmed this will be addressed through the scheme development and the ES.

Dave Hatcher asks about the risk items. Peter Taylor describes the risk items and the allowances made in the prices for unforeseen items for ecological mitigation.

Peter Taylor confirmed the Ground Investigation will commence on the 16th March. Jenny Emmett sought confirmation that there would be a watching archaeological watching brief. Russell Bennett confirmed there wouldn't be as the boreholes would only be 150mm diameter.

Peter Taylor confirmed the Bailey bridges will be approximately 25m span and

Item	Action and date required

not be situated in the rivers. They will be in place for up to 18 months. Russell Bennett confirmed the effects will be modelled as part of the overall flood modelling exercise. We are currently preparing flood modelling, Rivers Gywrfai, Rhyd, Seiont but not the River Cadnant.

Post meeting note: NRW have confirmed in their letter dated 10th April 2015 - With regard to flood defence matters, the temporary Bailey bridges referred to at the meeting, and mentioned in Section 4 of the minutes, will be subject to a Flood defence Consent (WRA 1991. S109) and must pass the design flood event 1% AEP (1 in 100) with freeboard and allowances for increased flows due to climate change.

Jill Jackson asks for opportunities for soil management and re-use of soil is appropriate to their re-use. Low maintenance grassland, inverted soils and local seed sources where possible.

Chris worker expressed concern about water particulates and pollution during construction. Peter Taylor confirmed there will be 14 attenuation ponds which are permanent but will be established early as they will be needed for water management and control of particulates.

Peter explained the earthworks strategy and that the tender design was not balanced. The design has been changed and modified to allow reuse of more excavated site won material, improve balance and hand more soft estate back to the landowners.

Chris Worker observed that that verges are a good opportunity for biodiversity. Lee Jones acknowledged this and confirmed this would be considered in detail as part of the EIA process.

Len Wyatt noted that there are only a few areas where the land could be returned to agriculture, rather than being the whole scheme.

Russell Bennett provided a description of the 2+1 carriageway layout. This alignment is required to accommodate the estimated traffic flows and to allow safe overtaking opportunity.

LJ confirmed we will ensure adequate land for maintenance access in the CPO.

PT confirmed the 'return to agriculture' proposals will be developed in scheme design and agreements with landowners.

Iwan Hughes confirmed the 7m requirements for access can be relaxed at the River Gwyrfai.

Emily Meilleur noted the scheme crosses a number of hedgerows. There was a discussion on the opportunity for translocation? Lee Jones confirmed this would be considered. It was noted that hedgerow translocation had mixed results and there are good and bad conditions for this activity. There was a debate about methodology and that specialist sub-contractors should be considered.

Chris Worker advised that WG are the Competent Authority for protected areas/species. He noted that bats and otters are both mobile species but in terms of stewardship of the landscape, the WG ask that any opportunities

Item	Action and date required

across the whole scheme to enhance habitat for these species are captured and taken.

Lee Jones noted that the culverts are sized for species and not flooding requirements.

The inter-relationship between the implications of doing one thing against another was discussed. For example, screening may be designed in planting, which then creates an issue which counters the ecological mitigation and increases maintenance liabilities. The mitigation measures will be developed to reflect impacts identified through the ES this has to consider impact at year of opening and the design year (year 15) longer term management will be addressed through the HEMP and taken by the trunk road agent.

Jill Jackson enquired where the Site Compound would be. Peter Taylor advised it was anticipated that it would be in the proximity of the Cibyn Industrial Estate. There would only be one main compound with minor satellite offices at key construction locations such as viaducts. There was also an intention to have a processing area to produce aggregates from the rock cutting. This would be placed as close as possible to the source of materials to minimise haulage. These areas would be included in environmental surveys.

Russell Bennett confirmed only the roundabouts will be lit on this scheme.

Len Wyatt raises the following items:

- Urban looking highway scheme in rural areas are not attractive and we should be looking to soften the engineering, with curves and make it feel less industrial/engineered.
- A bat report from work done on the Llanwnda scheme (post-monitoring) will be issued to the team in the next few weeks.
- INNS Directive is about to be issued covering invasive non-native species, such as Knotweed etc.
- The EC Directive on EIA was revised in 2014 and should be in place by 2017. Len Wyatt will keep people updated on what this means.
- The Water Framework Directive (WFD) applies to the Scheme. Len Wyatt will need to update the team early on with regards to our approach to WFD. The WG guidance will not be ready in time for our work on Caernarfon
- Peter Evans (NRW Bats) needs to be involved

Next meeting will be at approximately Week 20, which is the end of May. Invites and details will be issued closer to the time.

DISTRIBUTION: Attendees and copies to:

Approved by: Lee Jones Date: 27/03/2015

Issued by: Rachel Davies Date: 22/04/2015

MINUTES OF MEETING

Project	**A487 Caernarfon to Bontnewydd Bypass**
Subject	**Environmental Liaison Group Meeting 2**
Date	**21/10/2014**
Location	**The Management Centre, Bangor University Business School**
Meeting no.	**2**
Taken by	**Jeff Turner**
Participants	**Peris Jones – Welsh Government - Project Director (PJ)** **Ceri Evans – Welsh Government - Project Engineer (CE)** **Len Wyatt – Welsh Government - Environmental Advisor (LW)** **Chris Worker – Welsh Government - Nature Conservation Advisor (CW)** **David Hatcher – NRW – Lead Officer (DH)** **Dave Thorpe – NRW – Biodiversity Technical Specialist (DT)** **Iwan Huws – NRW – Development & Flood Risk Officer(IH)** **Bid Webb – NRW – Biodiversity Officer (BW)** **Mark Medway – NRW – Environment Officer (MM)** **Ashley Batten – Cadw – Planning Archaeologist North Wales (AB)** **Jenny Emmett – Gwynedd Archaeological Planning Service – Arch. Curator (JE)** **Ffion Muscroft – Gwynedd Council – Environmental Health Officer (FM)** **Rhys Jones – Gwynedd Council – Senior Biodiversity Officer (RJ)** **Owain Griffith – Gwynedd Council – Group Environmental Officer (OG)** **Jill Jackson – NMWTRA – Ecologist/Environmental Officer (JJ)** **Nigel Murphy – EC Harris – Employer's Agent (NM)** **Laura Clegg – Ramboll – Employer's Agent Project Engineer** **Hilary Morgan – Morgan Henshaw – Employer's Agent Env. Co-ordinator (HM)** **Jeff Turner – Ramboll – Employer's Agent Environmental Advisor (JT)**
Absent	**Mark Watson Jones (NMWTRA)**
Copy to	**All above**
Next meeting	**To be confirmed by ECI Contractor when appointed**

Date 21/10/2014

Ramboll
2nd Floor, The Exchange
St. John Street
Chester
CH1 1DA
United Kingdom

T +44(0)1244 311855
www.ramboll.co.uk

Ref 61032651

Agenda

1. **Welcome and Introductions**
2. **Aims and Objectives of the ELG – Purpose, Structure and Frequency**
3. **Project Background and Preferred Route**
4. **Programme and Milestones**
5. **Scheme Presentation and Environmental Sensitivities**
6. **Q&A/Group Discussion/Next Steps**
7. **Any Other Business**

1. Welcome and Introductions

Introductions were made around the table. PJ welcomed everyone and provided an overview of the Project and introduced the team, what had been undertaken to date and what was required going forward to deliver a successful scheme. NM introduced the role of Employer's Agent and the team.

2. Aims and Objectives of the ELG – Purpose, Structure and Frequency

HM discussed that the potential aims and objectives of the ELG going forward. HM explained that an ELG had been held in 2009 and that it was being reconvened given the length of time since the

INVESTORS IN PEOPLE | Silver

Ramboll UK Limited
Reg.no. 03659970

previous meeting. HM explained that it was up to the ECI contractor when appointed in December 2014 to organise the ELGs and the frequency of when they meet (likely to be quarterly).

HM stated that the aims and objectives of the ELG are to provide active stakeholder engagement, establish transparent and active links, raise and discuss issues and concerns and draw on best practice, local knowledge and previous experience. The ELGs are meant to facilitate the discussion of key issues and are to be concise and to the point, and are not to replace consultation. The aims and objectives of the ELG are to be confirmed once the ECI contractor is appointed.

3. Project Background and Preferred Route

JT provided a brief overview of the project background and what had been undertaken to date. Explained that a preferred route had been selected (Purple Route) based on a number of alternatives and the work undertaken during Key Stage 2 under WelTAG (Welsh Transport Assessment Guidance). However, this had been changed to the Yellow Route following Ministerial review in 2013.

The Yellow Route (preferred route) comprises a new 9.8km highway from the Goat Roundabout (A499/A487 junction) to the Plas Menai Roundabout. An outline design had been prepared which was tabled but it was emphasised that this was to be developed by the ECI Contractor when appointed. Scheme crosses a number of watercourses and is three lanes wide to provide overtaking opportunities.

LC provided a brief overview of the 19no structures in the outline design which currently comprise 7no bridges and 12no culverts.

JT explained why the project was needed and the transport objectives (reduce journey times, improve network resilience, improve safety etc).

4. Programme and Milestones

HM explained the programme and key milestones:

- Appointment of ECI Contractor – December 2014;
- Key Stage 3 – Approval of Preliminary Design – July 2015;
- Key Stage 3 – Publication of Draft Orders – January 2016;
- Key Stage 4 – Public Inquiry –July 2016;
- Key Stage 6 – Construction – January 2017 to June 2019 (including online improvements).

HM, PJ NM explained how the early contractor involvement process worked, and that Key Stage 3 would include preparation of Environmental Statement, baseline surveys, stakeholder engagement/consultation, public information exhibitions etc. Construction not due until 2017 and likely to require a public inquiry.

5. Scheme Presentation and Environmental Sensitivities

JT presented an overview of the key environmental sensitivities and the findings of the previous surveys and consultations.

6. Q&A/Group Discussion/Next Steps

MM raised concern that NRW had not been contacted prior to the tender documents being issued. JJ also queried what Early Contractor Involvement (ECI) was? NM and PJ explained how the ECI process worked emphasising that the design is still to be undertaken at this stage and that construction was not due for several years (and not likely before a public inquiry has taken place). It was also explained that the tender was written to allow a 'level playing field' to allow tender comparisons to be made (using mandatory assumptions etc) but these could be developed further by the ECI Contractor. PJ explained that the ECI Contractor would comprise a design consultant as well as a construction contractor.

LW went on to explain that there was a difference between preliminary design and detailed design. LW explained that detailed design is undertaken at the start of Key Stage 6 (construction phase). Preliminary design will be used to establish how much land take is required. LW stated that often too little land is identified so insufficient space for mitigation to be implemented.

PJ explained that there was a balance to be struck as they will need to justify the land take to the Inspector at public inquiry.

MM explained that the river catchments were sensitive particularly those with angling interests, soft drainage techniques needed therefore, land take must be sufficient to implement this.

CW highlighted risks of over specifying with regard to Habitat Regulations Assessment. If you have to provide compensation for European protected sites it is best to keep it relatively open and less detailed with regard to compensation parameters as it is difficult/ embarrassing to change later.

DH inquired how process worked if Contractor had made a financial commitment in the tender but a costly mitigation was required?

JJ asked if the contractor is preparing the Environmental Statement who polices that process to ensure that enough mitigation is specified? She raised the point that it is in the contractors interest to not find issues. JT and NM explained that the Employer's Agent role will protect the Government's interests and that the process is undertaken in accordance with legislation and best practice. NM briefly explained the ECI mechanism. JJ also asked if issues are found can the horizontal and vertical alignment be changed? PJ said that it was possible to change the preferred route, there was provision to move it a short distance horizontally (~67m) already and no significant restrictions vertically but these are to be assessed through the process.

CW asked whether objectors could use nature conservation arguments for their own gains? In his opinion it looks as if this is unlikely based on the preferred route.

Invasive species – DT raised issue that Japanese knotweed and Himalayan balsam are present on the Afon Gwyrfai and whether a spraying programme could be implemented now. JT and PG explained that this would be subject to landowner approvals and currently not allowed for by the contractor but could be included as one of the mitigation measures to drop out of the process. This could start potentially after the local public inquiry.

CW explained that the biggest risk during the construction phase in his opinion was sediment run off into the local watercourses (and ultimately into the Menai). He explained that local angling groups have access to legal teams to fight pollution incidents.

Bats – discussion on bats in the area and all agreed that the project should be looked at holistically, think of the scheme as a bat landscape. Impacts on the SAC raised as a concern. Need to consider tree clearance and minimise loss as 30-40 year old trees become the next generation of bat interest trees.

JT gave an overview of the results found during update surveys that had been undertaken since August 2014. These surveys confirmed results of the previous surveys, presence of lesser horseshoes throughout the scheme (as well as up to 6 other species).

JJ raised issues of otters, explained that there were a number of otter casualties in the area. This is likely as a result of otters moving between watercourses to hunt in ponds and wetlands as they were relatively close together (e.g. between Rivers Cadnant and Seiont, between Llanberis Road and Bethel Road). Need to develop a good baseline and search all records including casualties (e.g. Project Splatter).

Otter mitigation was discussed particularly use of fencing. Need to ensure there is sufficient landtake for otter fencing and not deter them from crossing between rivers. May need to put additional fencing in parallel to the road but this will be identified during Key Stage 3. Also need to be mindful that fencing does not act as 'debris collectors' when the rivers are in flood.

IH raised issue of the flood consequence assessments and design of structures. Discussed that FCA will need to consider 1 in 1000 year event plus climate change. Need to maintain greenfield runoff, other catchments keep separate.

LW discussed environmental design principles/objectives for the project, is there a condition to develop these within the ELGs? Advised that this had been undertaken on one of the Heads of the Valleys schemes in South Wales. For example, if there is an existing bat crossing point, it is maintained and that no overhead wire bat bridges are used, all bat passes would go under the road. Discussed carbon reduction v bats.

LW explained that where there are cuttings the bat mitigation options are limited.

Discussion of Eel and Water Framework Directives and how applied. LW explained that there had been some issues to date as to how the Water Framework Directive had been assessed on schemes and that this needed more clarity from NRW. DH explained that there

was currently training being undertaken on how this would be assessed. Helen Millband is the point of contact for NRW on Water Framework Directive.

Issues associated with eels and the directive, if applicable, can be discussed with Rob Evans at NRW.

JE and AB discussed heritage, explained that the Welsh Heritage Bill is likely to be part of legislation in March 2015. How would this affect the project? Raised point that the 'slate industries of North Wales' had been proposed as a World Heritage Site but not clear where the boundary of this would be. Stated that a site called 'Hen Gastell' south of the Goat Roundabout near Llanwnda was currently being investigated and that it could become a Scheduled Monument.

JE and AB raised the issue of potential undiscovered archaeology on the project. Recommended use of fieldwork, GPR and Lidar data, depending on the quality of the data can be used to identify hotspots. Highlighted that mitigation recommended for other disciplines could affect archaeology and heritage and will need to be considered in the round.

Noise/air quality/dust/vibration – FM explained that this will be for the contractor to undertake and they should liaise with Public Protection Service her officers to agree scope and methodologies etc. and how they will safeguard noise sensitive properties during the construction phase. Note that FM is not available during January 2015 and correspondence should be copied into llygredd@gwynedd.gov.uk .

JJ asked whether tree surveys were part of the scope of work and that mitigation in general should be over and above the minimum. JJ also asked that accessibility for maintenance is included (batter slope gradients etc).

Other issues to be included are translocation of hedges and trees where practicable, waste management and biodiversity enhancement.

7. Any Other Business

Next meeting likely to be in Q1 205 once the ECI Contractor had been appointed. Venue to be confirmed but likely to be in the Caernarfon area. Venue – good facilities but car parking at the university is limited. Most attendees arrived by car.

MINUTES OF MEETING

10 Park Grove
Cardiff CF10 3BI
T. 029 202 28966
F. 029 203 94776
cardiff@tacp.uk.c

27/29 Grosvenor
Wrexham LL11 1
T. 01978 291161
F. 01978 351735
wrexham@tacp.u

Project Number	60434	Page 1 of 5	
Project Title	A487 CAERNARFON – BONTNEWYDD STUDY		
Date of Meeting	24 November 2009	Location	Celtic Royal Hotel, Caernarfon
Purpose of Meeting	Environmental Liaison Group Meeting No. 1		
Prepared by	MB	Date of Circulation	19/01/2010
Approved by	LAJ	Date of Approval	19/01/2010

Present:		Circulation:
Mike Gilbert (MG)	WAG	All present
Phil Banks (PB)	WAG	Len Wyatt (WAG)
Alex Jones (AJ)	Gwynedd County Council / Gwynedd Consultancy	Tim Dorken (WAG)
Jill Jackson (JJ)	NWTRA	Carol Willgoose (WAG)
Rhys Jones (RJ)	Gwydnedd County Council	Emlyn Williams (NWTRA)
Peter Evans	CCW	Mannon Lewis (CCW)
Simon Hugheston-Roberts	CCW	Richard Glyn Jones (Gwynedd Council)
Ashley Batten (AB)	GAT	Jean Booker (Cadw)
Glyn Evans (GE)	Sustrans Cymru	
Iwan Huss (IH)	EA	
Gareth Thomas (GT)	EA	
Colin Riley (CR)	PB	
Kate Attwood (KA)	PB	
Lee Jones (LJ)	TACP	
Peter McComiskey (PMC)	TACP	
Max Burrell (MB)	TACP	

Architects
Environmental Consultants
Landscape Archit
Planners
Urban Designers
Interior Designers
Project Managers
Quantity Surveyo
Building Surveyo
Planning Supervis

Item **Action by:**

1.0 Welcome and Introductions

1.1 LJ welcomed all delegates to the 1st Environmental Liaison Group (ELG) meeting for the A487 Caernarfon – Bontnewydd Transportation Study. Each delegate introduced himself or herself and explained their role within their relevant organisation.

2.0 Transport Planning and the WelTAG Process

2.1 MG explained how the A487 Caernarfon – Bontnewydd study fitted into the overarching policy and strategies for Wales and summarised the Welsh Transport Appraisal Guidance (WelTAG) process.

2.2 The overarching policy comes from the 'One Wales' document, which is the agenda for the coalition government of Wales. This feeds into the National and Regional Transport Plans. The Caernarfon – Bontnewydd study is listed in the National Transport Plan for Wales.

2.3 Any WAG funded transport strategy or scheme must be subject to the WelTAG process. This has three main stages, which are the planning, appraisal and implementation stages. The A487 Caernarfon – Bontnewydd Study is currently moving towards the end of the appraisal stage (i.e. the Stage 2 Appraisal of Transportation Options is currently being undertaken).

3.0 Work undertaken so far and options currently being considered

3.1 CR summarised to delegates the work that had been undertaken so far and the transportation options that were currently being considered.

3.2 The WelTAG Planning Stage and Stage 1 Appraisal for the Caernarfon – Bontnewydd Study had been undertaken by other consultants (i.e. Arup). They had undertaken an analysis of transportation problems in the area, and from these problems developed a number of transport planning objectives (TPOs), which would need to be met by options proposed. Following this a series of transportation options were proposed and appraised during the Stage 1 WelTAG Appraisal.

3.3 The transportation options that were recommended to be taken to the Stage 2 Appraisal are as follows:

- Option 1 – New Bypass Llanwnda to Plas Meni
- Option 2 – Local Bypass (Llawnda, Dinas and Bontnewydd)
- Option 4 – Package of Online Measures
- Option 5 – Do minimum

3.4 Option 1 and 2 of the above options had a number of different routes associated with them, which bypass the towns and settlements both to the west and east. Following a stakeholder workshop and other work, the PB / TACP team have refined the options to be appraised at WelTAG Stage 2.

3.5 CR explained to delegates the thinking behind this option refinement. Some routes had been omitted due to economic and/or environmental reasons. For example Option 2, route 3 had been omitted due to too many river crossings. Also the eastern Option 2 routes had been taken out due to potential impacts on the Afon Gwyrfai a Llyn Cwellyn SSSI and SAC.

3.6 The transportation options that are currently being appraised at WelTAG Stage 2 are as follows:

- Option 1.4 – Purple Route (inner bypass to Felinheli)
- Option 1.8 – Yellow Route (inner bypass to Plas Menai)

Item **Action by:**

- Option 1.10 – Brown Route (upgrade to unofficial bypass)
- Option 2.2 – Pink Route (local bypass of Bontnewydd, Llanwnda and Dinas – common to all options)
- Option 5 – Do minimum (combination of local improvements to the existing network)

3.7 CR explained that the carriageway design that they were considering for the different options would be a WS2+1 carriageway . This standard provides directional overtaking opportunities at defined locations on the bypass routes. It is suitable for this route due to the traffic levels predicted in the opening and design years.

4.0 Environmental Issues

4.1 LJ summarised the main environmental issues associated with the project and the environmental work that was currently being undertaken.

4.2 LJ explained that since the start of the commission the Design Manual for Roads and Bridges Highways Design Advice Note HD44/09 'Assessment of implications (of highways and/or road projects) on European Sites (including appropriate assessment) had come into force. This ment that the study needed to consider potential impacts it may have on Natura 2000 Sites (i.e. Special Areas of Conservation (SACs), Special Protection Areas (SPAs) and Ramsar Sites). Any Natura 2000 site within a 30km radius of the study area needed to be considered particularly if they have a mobile species as a qualifying interest (e.g. bats, otters). HD44/09 can be downloaded from the following link:

http://www.standardsforhighways.co.uk/dmrb/vol11/section4/hd4409.pdf

4.3 Following a meeting with CCW on 24/03/2009 it was agreed that the Natura 2000 sites where impacts were most likely were the Afon Gwyrfai a Llyn Cwellyn SAC, Menai Strait and Conwy Bay SAC and Glynllifon SAC.

4.4 LJ summarised the ecological surveys that had been undertaken to inform the Stage 2 WelTAG Appraisal and Environmental Impact Assessment:

- Bat surveys have been undertaken. Of the fourteen sites surveyed, Lesser Horseshoe Bats had been detected at ten of the sites.
- Badger surveys had shown surprisingly little badger activity in the survey area.
- No Great Crested Newts were recorded in the study area.
- A number of Otter signs are present along various watercourses within the Study Area. Additionally, a mother and three Otter cubs were observed along the Afon Seiont during a bat survey.

4.5 LJ explained that there had been adjustments to the alignment of the routes being considered in the Stage 2 appraisal, in order to avoid favourable habitats and to take them further away from known bat roosts.

4.6 The position of the Purple route was realigned to minimise impacts on the setting of a Roman signal station.

4.7 It is acknowledged that all of the proposed options have potential environmental impacts and cross rivers that drain into the Menai Strait and Conwy Bay SAC. The crossing of rivers means that there will be a number of structures required, which give opportunities to incorporate wildlife crossings.

5.0 Issues raised by delegates

5.1 Following the ELG presentation, CR and LJ invited any questions or queries from

Item		Action by:
	delegates.	
5.2	GE raised a concern that Option 4 from WelTAG Stage 1 (Online package of Measures) was not included in the same form as it had at Stage 2 even though this option had scored the highest in the assessment against the Environmental, Economic and Social Welsh Impact Areas as well as scoring high in the TPO's. GE raised a concern that the 'do minimum / online improvements option' (Option 4) now being considered at Stage 2 offered little in the way of measures for pedestrians and cyclists and no detailed costings were being progressed for this option. He felt that measures for pedestrians and cyclists should not be removed at this stage. It was agreed that further consideration would be given to this option.	**PB**
5.3	GE also raised a concern that no provisions, such as shared use walkways and cycleways were proposed alongside any of the bypass options.	
5.4	CR stated that the study was more focused on trunk road issues. It was also highlighted that the bypass options would significantly reduce traffic along the A487, which could encourage more walking and cycling within communities and present opportunities for council lead walking and cycling projects.	
5.5	MG stated that the WAG will support schemes for walking and cycling through Regional Transport Plans.	
5.6	CR agreed to look into the possibility of incorporating measures for walking and cycling within the transportation options, especially between Bontnewydd and Cibyn.	**CR**
5.7	AB pointed out that there had recently been a large Roman settlement discovered along the Menai Strait in Anglesey. Any scheme that goes ahead therefore may have more potential than first thought for uncovering material of significant archaeological interest.	
5.8	AB also pointed out that the Brown Route (Option 1.10) comes into close proximity to the Cylan Tybod Ancient Monument, which is situated to the west of the option proposal, towards its northern end.	
5.9	CR explained in order to across the Welsh Highland Railway, west of Bontnewydd, the bypass would now have to be bridged over the railway rather than going beneath it as originally planned. With the level of topographical survey information available, it was not possible to confirm that the highway could go underneath the railway because of drainage issues. This should be checked again at Stage 3 (ECI Phase) of the project.	
5.10	It is acknowledged that the bridging of the Welsh Highland Railway will have a detrimental landscape impact, as the road will be on an embankment in a largely flat landscape.	
5.11	PMC explained how they would seek to minimise potential landscape impacts. The embankment would be graded out and returned to agricultural use to fit in with the landscape. They would seek to avoid excessive screen planting as this may cause an inappropriate linear block of trees within the landscape. Mitigation would be explored during the Stage 2 Assessment.	
5.12	GT and IH inquired to what flood event probability would the proposals be designed? CR stated he could consult with PB Hydrological Engineers and advise.	**CR**
5.13	JJ raised a concern that the embankments associated with the various options could make Barn Owls more vulnerable to collisions with cars.	
5.14	KA stated that geological constraints such as landfill sites and mineral resources had been considered as part of the study.	
6.0	**Any Other Business**	

Item		Action by:
6.1	There was no other business.	
6.2	CR and LJ thanked all delegates for attending. The time, date and venue of the next ELG meeting will be confirmed closer to the time.	

Appendix A.4 – WelTAG KS2 Appraisal Summary Tables

Pink Option

Pink Option Description – The Pink Option is a 3.4km route to the south west of Caernarfon. It forms part of all full bypass options or alternatively could be a standalone scheme as a bypass of Llanwnda and Bontnewydd. This option begins at the A499/A487 roundabout to the south of Llanwnda, runs north and to the west of Llanwnda before deviating east and reconnecting with the A487 just north of Bontnewydd at a new roundabout. From the A499/A487 roundabout the road is on an embankment for a short length before entering a cutting where a minor road crosses on an overbridge. On leaving the cutting the road is on embankment for the remainder of its length. It crosses the Afon Gwyrfai floodplain on a long viaduct and over the Highland Railway on an underbridge. Between the Afon Gwyrfai and the A487, two side roads are accommodated with box culverts.			
Appraisal Criteria	**Assessment**	**Distribution**	**Significance**
Economy			
Transport Economic Efficiency	Scheme Costs: £40.8M PVC: £46.0M PVB: £164.8M NPV: £118.8M BCR: 3.58	All road users to benefit from reduced journey times and vehicle operating costs	Moderate Beneficial (++)
EALI (wider economic Impacts)	This option has the potential to open up development possibilities at new junction locations. The bypass may also act as a boundary to which development within Bontnewydd may encroach.	The local economy will benefit.	Slight Beneficial (+)
Environment			
Noise	The Pink Option results in traffic being diverted off the current A487 through Bontnewydd along which many NSRs currently occupy roadside positions. This results in significant traffic reductions along this current route. Again resulting in a significant number of NSRs experiencing reductions in traffic noise. A number of NSRs that currently experience very little traffic noise will experience small increases in traffic noise along the new route by-passing Bontnewydd.	Bontnewydd	Moderate Beneficial (++)
Local Air Quality	2473 and 1956 properties will experience an increase in PM_{10} and NO_2 respectively. 386 and 903 properties will experience a reduction in PM_{10} and NO_2 respectively.	Benefits weighted to residents in less affluent areas of housing, adjacent to the existing A487(T) . Assessment refers to entire study area from Llanwnda to Felinheli.	Slight Beneficial (+)
Greenhouse Gas Emissions	CO_2 emissions – decrease of 623 tonnes in opening year. NPV of cost £1,051,000		Moderate Beneficial (++)
Landscape and townscape	Proposals include elements contradictory to existing topography and result in the loss of field patterns, boundaries and woodland. Introduction of engineered element into rural landscape affects both townscape character and visual	Welsh Highland Railway crossing in particular.	Slight Adverse (-)

Pink Option Description – The Pink Option is a 3.4km route to the south west of Caernarfon. It forms part of all full bypass options or alternatively could be a standalone scheme as a bypass of Llanwnda and Bontnewydd. This option begins at the A499/A487 roundabout to the south of Llanwnda, runs north and to the west of Llanwnda before deviating east and reconnecting with the A487 just north of Bontnewydd at a new roundabout. From the A499/A487 roundabout the road is on an embankment for a short length before entering a cutting where a minor road crosses on an overbridge. On leaving the cutting the road is on embankment for the remainder of its length. It crosses the Afon Gwyrfai floodplain on a long viaduct and over the Highland Railway on an underbridge. Between the Afon Gwyrfai and the A487, two side roads are accommodated with box culverts.			
Appraisal Criteria	**Assessment**	**Distribution**	**Significance**
	context.		
Bio-diversity	There is a crossing of the Afon Gwyrfai which is designated as a SAC and SSSI and is the most important feature potentially impacted upon. In this location there are potential impacts upon Otter, fish species, habitats, bat feeding sites etc.. At the location where the Afon Gwyrfai is crossed there is relatively limited riparian habitat however so the impact would be reduced, also it is understood that the road would pass over the river at height with no structures in the river therefore reducing impacts. Bats, Otters, breeding birds, fish and Brown Hare are all likely to be impacted upon. The impact is considered to be Moderate adverse where the Afon Gwyrfai is being crossed (this could be downgraded by careful mitigation and programming of works). There will be slight/moderate adverse impacts where the Felinwnda Wildlife Site is impacted and possibly where the option passes close to areas of marshy grassland. The impact upon bats, otters and fish is also considered to be slight/moderate with generally slight adverse impacts over much of the habitat to be impacted and other species.	The most significant potential impacts are focused upon the Afon Gwyrfai with valuable habitats and protected species concentrated within this area. Potential impacts are generally much reduced over the majority of this option, although the widespread distribution of bats and particularly Lesser Horseshoe Bats needs to be given particular consideration.	Slight/Moderate Adverse (-/--)
Heritage	No physical effect on any SAM or Listed Building. No physical impact on any non-statutory archaeological sites. Moderate adverse impact on the historic setting of one Grade II Listed Building.	Bontnewydd / Dinas area	Slight Adverse (-)
Water environment	The construction of a new road through a 'greenfield' will increase surface water runoff, obstruct flood flow within the flood plain and cause a loss of flood plain storage if no mitigation measures are established. The significance of effect has been determined for the design year and post-mitigation.	All watercourses along the Pink Option corridor, including Afons Beuno, Gwyrfai and Rhyd.	Moderate Adverse (--)
Soils	The possible impact from the construction of embankments along the route	Bontnewydd / Dinas area	Slight Adverse (-)
Society			
Transport safety	Number of accidents saved: 3,574 – 3,069 = 505 PVB = £172.2M - £147.2M = £25M The 2+1 carriageway standard provides safe overtaking opportunities.	All road users	Neutral (0)
Personal security		General population throughout Bontnewydd,	Neutral (0)

Pink Option Description – The Pink Option is a 3.4km route to the south west of Caernarfon. It forms part of all full bypass options or alternatively could be a standalone scheme as a bypass of Llanwnda and Bontnewydd. This option begins at the A499/A487 roundabout to the south of Llanwnda, runs north and to the west of Llanwnda before deviating east and reconnecting with the A487 just north of Bontnewydd at a new roundabout. From the A499/A487 roundabout the road is on an embankment for a short length before entering a cutting where a minor road crosses on an overbridge. On leaving the cutting the road is on embankment for the remainder of its length. It crosses the Afon Gwyrfai floodplain on a long viaduct and over the Highland Railway on an underbridge. Between the Afon Gwyrfai and the A487, two side roads are accommodated with box culverts.

Appraisal Criteria	**Assessment**	**Distribution**	**Significance**
		Dinas Caernarfon and surrounding settlements.	
Permeability	The bypass will substantially reduce community severance within the settlements of Bontnewydd and Dinas by reducing predicted traffic flows (AADT) along the A487.	Relief from severance limited to communities of Bontnewydd and Dinas	Large Beneficial (+++)
Physical Fitness	Without direct provision for cyclist and pedestrians, the bypass does nothing directly to encourage active modes of transport within Bontnewydd, Dinas or Caernarfon. However the reduction of congestion through Bontnewydd and Dinas may encourage more travel by active modes such as walking and cycling.	General population throughout Bontnewydd and Dinas. No benefit to wider study area.	Slight Adverse (-)
Social Inclusion	Benefits to journey times for populations west and south of Bontnewydd and increases accessibility contour lengths.	Populations to the west and south of Bontnewydd	Slight Beneficial (+)
Equality, Diversity & Human Rights	The Option is unlikely to have any impacts in relation to the equality impact groups.	General population throughout Bontnewydd, Dinas Caernarfon and surrounding settlements.	Neutral (0)
Transport Planning Objectives			
TPO 1	**Moderate Beneficial (++)** By 2016 journey time reduced by an average of 3 minutes throughout the day between Llanwnda and Plas Menai This reduction meets the requirement of the TPO.		
TPO 2	**Moderate Beneficial (++)** By 2016 journey time reduced by an average of 3 minutes throughout the day between Llanwnda and Caernarfon. This reduction meets the requirement of the TPO.		
TPO 3	**Slight Adverse (-)** By 2016 the number of vehicles through Dinas along the A487 reduces by 75% based on AADT flow. By 2016 the number of vehicles through Caernarfon along the A487 increases by 5% based on AADT flow.		
TPO 4	**Slight Adverse (-)** By 2016 accidents increase 4% along the A487. This does not meet the requirement of a 22% reduction detailed in the TPO.		
TPO 5	**Slight Beneficial (+)** Improved network resilience; by-pass provides improved journey times and delays from south to north.		

Pink Option Description – The Pink Option is a 3.4km route to the south west of Caernarfon. It forms part of all full bypass options or alternatively could be a standalone scheme as a bypass of Llanwnda and Bontnewydd. This option begins at the A499/A487 roundabout to the south of Llanwnda, runs north and to the west of Llanwnda before deviating east and reconnecting with the A487 just north of Bontnewydd at a new roundabout. From the A499/A487 roundabout the road is on an embankment for a short length before entering a cutting where a minor road crosses on an overbridge. On leaving the cutting the road is on embankment for the remainder of its length. It crosses the Afon Gwyrfai floodplain on a long viaduct and over the Highland Railway on an underbridge. Between the Afon Gwyrfai and the A487, two side roads are accommodated with box culverts.			
Appraisal Criteria	**Assessment**	**Distribution**	**Significance**
Public acceptability:	Acceptable to public living along the existing A487 within Llanwnda, Dinas and Bontnewydd. Does little for Caernarfon. CPO required across the entire route. There are 11 properties directly affected (within 100m of the route).		
Acceptability to other stakeholders:	Acceptable to local councils affected (Dinas etc). Again perception does little for other areas including Bethel and Pont-Rug. Consultation with EA on flooding of Gwyrfai – structure modified to suit. CCW consulted on SAC and SSSI issues. Western route acceptable.		
Technical and operational feasibility:	No departures or relaxations, built to full 2+1 standard. Flood relief structure over Afon Gwyrfai – significant structure for size of scheme. Welsh Highland Railway – likely some closure / possession required. Deficit in E/W quantities.		
Financial affordability and deliverability:	Relatively high cost per m (£11.8M/km) due to large structures and need for import.		
Risks:	Does not solve the wider transport implications of the area. Funding risks are known and manageable. Flood modelling required at future stages.		
Comment:			

White Option

White Option Description – The White Option is a 3.75km route to the south of Caernarfon and is an alternative to the Pink Option for bypassing Llanwnda and Bontnewydd. The option begins at the A499/A487 Goat roundabout to the south of Llanwnda running in a north easterly direction, to the east of Llanwnda and Bontnewydd, before deviating west and reconnecting with the A487 just north of Bontnewydd at a new roundabout. The road is on an embankment for the majority of its length with a total of twelve new structures. These comprise six underbridges (including two of which that are viaducts), one overbridge, one pipe culvert and four box culverts. The underbridges, overbridge and culverts deal with seven watercourses (including the Rivers Gwyrfai and Beuno), six roads, a railway, a public footpath and Gypsy Wood Park.			
Appraisal Criteria	**Assessment**	**Distribution**	**Significance**
Economy			
Transport Economic Efficiency	Scheme Costs: £66.9M PVC: £71.5M PVB: £139.2M NPV: £67.6M BCR: 1.95	All road users to benefit from reduced journey times and vehicle operating costs	Slight Beneficial (+)
Wider Economic Impacts - EALI	This option has the potential to open up development possibilities at new junction locations. The bypass may also act as a boundary to which development within Bontnewydd may encroach.	The local economy will benefit.	Slight Beneficial (+)
Environment			
Noise	The White Option results in traffic being diverted off the current A487 through Bontnewydd along which many NSRs currently occupy roadside positions. This results in significant traffic reductions along this current route. In the opening year more properties will see a noise decrease than an increase and therefore the option can be considered moderately noise beneficial. However 137 properties will experience an *increase* of greater than 3dB in the opening year.	Bontnewydd	Moderate Beneficial (++)
Local Air Quality	992 properties will experience an increase in PM_{10} and NO_2 respectively. 1894 properties will experience a reduction in PM_{10} and NO_2 respectively.	Benefits weighted towards the residents of Bontnewydd and Dinas along the A487.	Slight Beneficial (+)
Greenhouse Gas Emissions	CO_2 emissions – decrease of 612 tonnes in opening year. NPV of cost £1,014,000		Moderate Beneficial (++)
Landscape and townscape	The White Option proposal cuts through a rural landscape with an embankment form being contradictory to the prevailing topography. The middle section traverses the elevated slopes on the edge of the coastal plain, making it visible in the landscape to the west. In some views this section of road embankment will appear on the middle distance horizon. The crossing of the Afon Gwyrfai valley is particularly damaging to this	Afon Gwyrfai valley crossing and its approaches.	Slight Adverse (-)

White Option Description – The White Option is a 3.75km route to the south of Caernarfon and is an alternative to the Pink Option for bypassing Llanwnda and Bontnewydd. The option begins at the A499/A487 Goat roundabout to the south of Llanwnda running in a north easterly direction, to the east of Llanwnda and Bontnewydd, before deviating west and reconnecting with the A487 just north of Bontnewydd at a new roundabout. The road is on an embankment for the majority of its length with a total of twelve new structures. These comprise six underbridges (including two of which that are viaducts), one overbridge, one pipe culvert and four box culverts. The underbridges, overbridge and culverts deal with seven watercourses (including the Rivers Gwyrfai and Beuno), six roads, a railway, a public footpath and Gypsy Wood Park.			
Appraisal Criteria	**Assessment**	**Distribution**	**Significance**
	extremely enclosed landscape and introduces incongruous earthworks on its approaches. However this impact is localised and the wider effect limited by the nature of the existing landform. This Option has little impact on townscape, having only a minor indirect effect on one part of Bontnewydd. As with other options the route results in the loss of field boundaries, woodland, trees and a disruption of the landscape pattern.		
Bio-diversity	There is a crossing of the Afon Gwyrfai which is designated as a SAC and SSSI, this is the most important feature potentially impacted upon. In this location there are potential impacts upon Otter, fish species, habitats, bat feeding sites etc. At the location where the Afon Gwyrfai is crossed there is considerable riparian habitat with a substantial area of SSSI woodland flanking the river on both sides making the impact greater. It is understood that the road would pass over the river at height with no structures in the river therefore reducing impacts on the SAC but less so on the SSSI. Bats, Otters, Barn Owls, breeding birds, reptiles, amphibians, fish and Brown Hare are all likely to be impacted upon. The impact is considered to be Slight/Moderate adverse where the Ty'n-Y-Coed Wildlife Site (candidate) is being crossed. The major impact is however where the Afon Gwyrfai is being crossed it is considered that the impact upon the River itself and the SAC designation is adverse moderate with the impact on the woodland SSSI being large adverse. The impact upon otters and bats is considered to be moderate with slight/moderate impacts upon breeding birds, fish and Badgers. The impacts are however generally slight adverse over much of the rest of the habitat to be impacted and other species. The impact is considered to be less than the Blue Option because it crosses the Afon Gwyrfai further west where the SSSI is 80m wide as opposed to 180m.	The most significant potential impacts are focused upon the Afon Gwyrfai with potential impacts upon the river and its SAC designation and particularly upon the flanking woodland and its SSSI designation. Potential impacts are generally much reduced over the rest of this option, although the impacts on Wildlife Sites and protected species, and particularly the widespread distribution of bats (especially Lesser Horseshoe Bats) needs particular consideration.	Large Adverse (---)
Heritage	No effect upon known cultural heritage assets during construction and operation. Potential impact upon new (i.e. undiscovered) archaeological sites is unknown	N/A	Neutral (0)
Water environment	The assessment of the magnitude of impacts is after mitigation measures have been established. Mitigation includes the attenuation of surface water runoff before discharging into watercourses, installing pollution control measures in high risk areas, crossing of watercourses to span the entire floodplain, adding culverts at road crossings and increasing existing culvert sizes at road crossings.	Water courses within the study area affected by the route	Neutral (0)
Soils	The possible impact from the construction of embankments along the route and the large structure across the Afon Gwyrfai.	Bontnewydd / Dinas area	Slight Adverse

White Option Description – The White Option is a 3.75km route to the south of Caernarfon and is an alternative to the Pink Option for bypassing Llanwnda and Bontnewydd. The option begins at the A499/A487 Goat roundabout to the south of Llanwnda running in a north easterly direction, to the east of Llanwnda and Bontnewydd, before deviating west and reconnecting with the A487 just north of Bontnewydd at a new roundabout. The road is on an embankment for the majority of its length with a total of twelve new structures. These comprise six underbridges (including two of which that are viaducts), one overbridge, one pipe culvert and four box culverts. The underbridges, overbridge and culverts deal with seven watercourses (including the Rivers Gwyrfai and Beuno), six roads, a railway, a public footpath and Gypsy Wood Park.

Appraisal Criteria	Assessment	Distribution	Significance
Society			
Transport safety	Number of accidents saved: 3574 – 3279 = 295 PVB = £172.2M - £158.2M = £14.0M The 2+1 carriageway standard provides safe overtaking opportunities.	All road users	Slight Beneficial (+)
Personal security		General population throughout Bontnewydd, Dinas Caernarfon and surrounding settlements.	Neutral (0)
Permeability	The bypass will substantially reduce community severance within the settlements of Bontnewydd and Dinas by reducing predicted traffic flows (AADT) along the A487.	Relief from severance limited to communities of Bontnewydd and Dinas	Large Beneficial (+++)
Physical Fitness	Without direct provision for cyclist and pedestrians, the bypass does nothing directly to encourage active modes of transport within Bontnewydd, Dinas or Caernarfon. However the reduction of congestion through Bontnewydd and Dinas may encourage more travel by active modes such as walking and cycling. Loss of Bontnewydd football ground.	General population throughout Bontnewydd and Dinas. No benefit to wider study area.	Slight Adverse (-)
Social Inclusion	Benefits to journey times for populations west and south of Bontnewydd and increases accessibility contour lengths. Improved access to facilities within settlements. Bypass will provide an enhanced route for access to facilities.	Populations to the west and south of Bontnewydd	Slight Beneficial (+)
Equality, Diversity & Human Rights	The Option is unlikely to have any impacts in relation to the equality impact groups.	General population throughout Bontnewydd, Dinas Caernarfon and surrounding settlements.	Neutral (0)
Transport Planning Objectives			
TPO 1	**Slight Beneficial (+)**		

White Option Description – The White Option is a 3.75km route to the south of Caernarfon and is an alternative to the Pink Option for bypassing Llanwnda and Bontnewydd. The option begins at the A499/A487 Goat roundabout to the south of Llanwnda running in a north easterly direction, to the east of Llanwnda and Bontnewydd, before deviating west and reconnecting with the A487 just north of Bontnewydd at a new roundabout. The road is on an embankment for the majority of its length with a total of twelve new structures. These comprise six underbridges (including two of which that are viaducts), one overbridge, one pipe culvert and four box culverts. The underbridges, overbridge and culverts deal with seven watercourses (including the Rivers Gwyrfai and Beuno), six roads, a railway, a public footpath and Gypsy Wood Park.

Appraisal Criteria	Assessment	Distribution	Significance
	By 2016 journey time reduced by an average of 1 minute throughout the day between Llanwnda and Plas Menai. Although the scheme reduces the journey time along the route it does not meet the requirements of the TPO.		
TPO 2	**Slight Beneficial (+)** By 2016 journey time reduced by an average of 1 minute throughout the day between Llanwnda and Caernarfon. Although the scheme reduces the journey time along the route it does not meet the requirements of the TPO.		
TPO 3	**Slight Adverse (-)** By 2016 the number of vehicles through Dinas along the A487 reduces by 71% based on AADT flow. By 2016 the number of vehicles through Caernarfon along the A487 increases by 13% based on AADT flow.		
TPO 4	**Slight Adverse (-)** By 2016 accidents increase by 11% along the A487. This does not meet the requirement of the TPO.		
TPO 5	**Slight Beneficial (+)** Improved network resilience; by-pass provides improved journey times and delays from south to north.		
Public acceptability:	Acceptable to public living along the existing A487 within Llanwnda, Dinas and Bontnewydd. Does little for Caernarfon. CPO required across the entire route. Uses land which is of poorer agricultural value compared to western route. Significant adverse impact upon Gypsy Wood and local football ground. Passes within 30m to the west of Plas-y-Bryn Chalet Park & Nursing Home. 4 residential buildings & 1 business within 25m of route; in total 22 properties are actually within 100m of the route. Greater disruption to local highway network during construction due to reconstruction of Goat.		
Acceptability to other stakeholders:	Acceptable to local councils affected (Dinas etc). Again perception does little for other areas including Bethel and Pont-Rug. CCW consulted on structure over Afon Gwyrfai, SAC & SSSI. Unacceptable to CCW due to impact on SAC and SSSI to the east of Bontnewydd. Adverse impact upon Plas-y-Bryn Chalet Park & Nursing Home and Gypsy Wood tourist attraction.		
Technical and operational feasibility:	One relaxation (510 horizontal radius at 100kph). On embankment for approximately 90% of route. Maximum height of embankment is 19m. Substantial importation of construction material. Large structure required to cross Afon Gwyrfai and associated SSSI and SAC - significant structure for size of scheme and complex construction required. Access for construction limited. Welsh Highland Railway – likely some closure / possession required and highly skewed structure. Re-construction of Goat roundabout required.		
Financial affordability and deliverability:	30% increase in cost of structure to cross Afon Gwyrfai and associated SSSI and SAC due to complexity of construction. Very high cost per km (£17.7M/km).		

White Option Description – The White Option is a 3.75km route to the south of Caernarfon and is an alternative to the Pink Option for bypassing Llanwnda and Bontnewydd. The option begins at the A499/A487 Goat roundabout to the south of Llanwnda running in a north easterly direction, to the east of Llanwnda and Bontnewydd, before deviating west and reconnecting with the A487 just north of Bontnewydd at a new roundabout. The road is on an embankment for the majority of its length with a total of twelve new structures. These comprise six underbridges (including two of which that are viaducts), one overbridge, one pipe culvert and four box culverts. The underbridges, overbridge and culverts deal with seven watercourses (including the Rivers Gwyrfai and Beuno), six roads, a railway, a public footpath and Gypsy Wood Park.

Appraisal Criteria	**Assessment**	**Distribution**	**Significance**
Risks:	Does not solve the wider transport implications of the area. Funding risks are known and manageable. Complex construction required. High risk from statutory objections. Flood modelling required at future stages.		
Comment:			

Blue Option

Blue Option Description – The Blue Option is a 4km route to the south of Caernarfon and is an alternative to the Pink and White Options for bypassing Llanwnda and Bontnewydd. The option begins at the A499/A487 roundabout, to the south of Llanwnda, running in a north easterly direction along the same alignment as the White Option for the first 850m. The route then runs in the same direction as the White Option but slightly further east of Llanwnda and Bontnewydd before deviating west and reconnecting with the A487 just north of Bontnewydd at a new roundabout. As with the White Option the road is on an embankment for the majority of its length with several structures required to pass over the same road and water courses as the White Option. The structures include two viaducts to pass over the Rivers Gwyrfai and Beuno.

Appraisal Criteria	Assessment	Distribution	Significance
Economy			
Transport Economic Efficiency	Scheme Costs: £63.4M PVC: £67.6M PVB: £130.1M NPV: £62.6M BCR: 1.93	All road users to benefit from reduced journey times and vehicle operating costs	Slight Beneficial (+)
EALI (wider economic Impacts)	This option has the potential to open up development possibilities at new junction locations. The bypass may also act as a boundary to which development within Bontnewydd may encroach.	The local economy will benefit.	Slight Beneficial (+)
Environment			
Noise	The Blue Option results in traffic being diverted off the current A487 through Bontnewydd along which many NSRs currently occupy roadside positions. In the opening year more properties will see a noise decrease than an increase and therefore the option can be considered moderately noise beneficial. However, 139 properties will experience an *increase* of greater than 3dB in the opening year.	Bontnewydd	Moderate Beneficial (++)
Local Air Quality	978 and 983 properties will experience an increase in PM_{10} and NO_2 respectively. 1894 and 1889 properties will experience a reduction in PM_{10} and NO_2 respectively.	Benefits weighted towards the residents of Bontnewydd and Dinas along the A487. Assessment refers to entire study area from Llanwnda to Felinheli.	Slight Beneficial (+)
Greenhouse Gas Emissions	CO_2 emissions – decrease of 578 tonnes in the opening year NPV of cost £914,000		Moderate Beneficial (++)
Landscape and townscape	The Blue Option proposal cuts through a rural landscape with an embankment form being contradictory to the prevailing topography. The middle section traverses the elevated slopes on the edge of the coastal plain, although being east of the scarp edge it is less visible in the landscape to the west. The	Afon Gwyrfai valley crossing and its approaches.	Slight Adverse (-)

Blue Option Description – The Blue Option is a 4km route to the south of Caernarfon and is an alternative to the Pink and White Options for bypassing Llanwnda and Bontnewydd. The option begins at the A499/A487 roundabout, to the south of Llanwnda, running in a north easterly direction along the same alignment as the White Option for the first 850m. The route then runs in the same direction as the White Option but slightly further east of Llanwnda and Bontnewydd before deviating west and reconnecting with the A487 just north of Bontnewydd at a new roundabout. As with the White Option the road is on an embankment for the majority of its length with several structures required to pass over the same road and water courses as the White Option. The structures include two viaducts to pass over the Rivers Gwyrfai and Beuno.

Appraisal Criteria	Assessment	Distribution	Significance
	crossing of the Afon Gwyrfai valley is particularly damaging to this extremely enclosed landscape with the extreme earthworks and structure required and the loss of woodland. However this impact is localised and the wider effect limited by the nature of the existing landform and vegetation. This Option has no impact on townscape. As with other options the route results in the loss of field boundaries, woodland, trees and a disruption of the landscape pattern.		
Bio-diversity	There is a crossing of the Afon Gwyrfai which is designated as a SAC and SSSI, this is the most important feature potentially impacted upon. In this location there are potential impacts upon Otter, fish species, habitats, bat feeding sites etc. At the location where the Afon Gwyrfai is crossed there is considerable riparian habitat with a substantial area of SSSI woodland flanking the river on both sides making the impact greater. It is understood that the road would pass over the river at height with no structures in the river therefore reducing impacts on the SAC but less so on the SSSI. Bats, Otters, Barn Owls, breeding birds, reptiles, amphibians, fish and Brown Hare are all likely to be impacted upon. The impact is considered to be Slight/Moderate adverse where the Ty'n-Y-Coed Wildlife Site (candidate) is being crossed. The major impact is however where the Afon Gwyrfai is being crossed it is considered that the impact upon the River itself and the SAC designation is adverse moderate with the impact on the woodland SSSI being large adverse. The impact upon otters and bats is considered to be moderate with slight/moderate impacts upon breeding birds, fish and Badgers. The impacts are however generally slight adverse over much of the rest of the habitat to be impacted and other species. The impact is considered to be greater than the White Option because it crosses the Afon Gwyrfai further east where the SSSI is 180m wide as opposed to 80m.	The most significant potential impacts are focused upon the Afon Gwyrfai with potential impacts upon the river and its SAC designation and particularly upon the flanking woodland and its SSSI designation. Potential impacts are generally much reduced over the rest of this option, although the impacts on Wildlife Sites and protected species, and particularly the widespread distribution of bats (especially Lesser Horseshoe Bats) needs particular consideration.	Large Adverse (---)
Heritage	No effect upon known cultural heritage assets during construction and operation. Potential impact upon new (i.e. undiscovered) archaeological sites is unknown	N/A	Neutral (0)
Water	The assessment of the magnitude of impacts is after mitigation measures	Water courses within the study	Neutral

Blue Option Description – The Blue Option is a 4km route to the south of Caernarfon and is an alternative to the Pink and White Options for bypassing Llanwnda and Bontnewydd. The option begins at the A499/A487 roundabout, to the south of Llanwnda, running in a north easterly direction along the same alignment as the White Option for the first 850m. The route then runs in the same direction as the White Option but slightly further east of Llanwnda and Bontnewydd before deviating west and reconnecting with the A487 just north of Bontnewydd at a new roundabout. As with the White Option the road is on an embankment for the majority of its length with several structures required to pass over the same road and water courses as the White Option. The structures include two viaducts to pass over the Rivers Gwyrfai and Beuno.			
Appraisal Criteria	**Assessment**	**Distribution**	**Significance**
environment	have been established. Mitigation includes the attenuation of surface water runoff before discharging into watercourses, installing pollution control measures in high risk areas, crossing of watercourses to span the entire floodplain, adding culverts at road crossings and increasing existing culvert sizes at road crossings.	area affected by the route	(0)
Soils	The possible impact from the construction of embankments along the route and the large structure across the Afon Gwyrfai.	Bontnewydd / Dinas area	Slight Adverse (-)
Society			
Transport safety	Number of accidents saved: 3574 – 3302 = 272 PVB = £172.2M - £159.5M = £12.7M The 2+1 carriageway standard provides safe overtaking opportunities.	All road users	Slight Beneficial (+)
Personal security		General population throughout Bontnewydd, Dinas Caernarfon and surrounding settlements.	Neutral (0)
Permeability	The bypass will substantially reduce community severance within the settlements of Bontnewydd and Dinas by reducing predicted traffic flows (AADT) along the A487.	Relief from severance limited to communities of Bontnewydd and Dinas	Large Beneficial (+++)
Physical Fitness	Without direct provision for cyclist and pedestrians, the bypass does nothing directly to encourage active modes of transport within Bontnewydd, Dinas or Caernarfon. However the reduction of congestion through Bontnewydd and Dinas may encourage more travel by active modes such as walking and cycling.	General population throughout Bontnewydd and Dinas. No benefit to wider study area.	Slight Adverse (-)
Social Inclusion	Benefits to journey times for populations west and south of Bontnewydd and increases accessibility contour lengths. Improved access to facilities within settlements. Bypass will provide an enhanced route for access to facilities.	Populations to the west and south of Bontnewydd	Slight Beneficial (+)
Equality, Diversity & Human	The Option is unlikely to have any impacts in relation to the equality impact groups.	General population throughout Bontnewydd, Dinas Caernarfon and surrounding settlements.	Neutral (0)

Blue Option Description – The Blue Option is a 4km route to the south of Caernarfon and is an alternative to the Pink and White Options for bypassing Llanwnda and Bontnewydd. The option begins at the A499/A487 roundabout, to the south of Llanwnda, running in a north easterly direction along the same alignment as the White Option for the first 850m. The route then runs in the same direction as the White Option but slightly further east of Llanwnda and Bontnewydd before deviating west and reconnecting with the A487 just north of Bontnewydd at a new roundabout. As with the White Option the road is on an embankment for the majority of its length with several structures required to pass over the same road and water courses as the White Option. The structures include two viaducts to pass over the Rivers Gwyrfai and Beuno.			
Appraisal Criteria	**Assessment**	**Distribution**	**Significance**
Rights			
Transport Planning Objectives			
TPO 1	**Slight Beneficial (+)** By 2016 journey time reduced by an average of 1 minute throughout the day between Llanwnda and Plas Menai. Although the scheme reduces the journey time along the route it does not meet the requirements of the TPO.		
TPO 2	**Slight Beneficial (+)** By 2016 journey time reduced by an average of 1 minute throughout the day between Llanwnda and Caernarfon. Although the scheme reduces the journey time along the route it does not meet the requirements of the TPO.		
TPO 3	**Slight Adverse (-)** By 2016 the number of vehicles through Dinas along the A487 reduces by 70% based on AADT flow. By 2016 the number of vehicles through Caernarfon along the A487 increases by 13% based on AADT flow.		
TPO 4	**Slight Adverse (-)** By 2016 accidents increase by 10% along the A487. This does not meet the requirement of the TPO.		
TPO 5	**Slight Beneficial (+)** Improved network resilience; by-pass provides improved journey times and delays from south to north.		
Public acceptability:	Acceptable to public living along the existing A487 within Llanwnda, Dinas and Bontnewydd. Does little for Caernarfon. CPO required across the entire route. Uses land which is of poorer agricultural value compared to western route. Significant adverse impact upon Gypsy Wood. Passes within 60m east of Plas-y-Bryn Chalet Park & Nursing Home. 3 residential buildings & 1 business within 25m of route. Greater disruption to local highway network during construction, due to reconstruction of the Goat.		
Acceptability to other stakeholders:	Acceptable to local councils affected (Dinas etc). Again perception does little for other areas including Bethel and Pont-Rug. CCW consulted on structure over Afon Gwyrfai, SAC & SSSI. Unacceptable to CCW due to impact on SAC and SSSI to the east of Bontnewydd. Adverse impact upon Plas-y-Bryn Chalet Park & Nursing Home and Gypsy Wood tourist attraction.		
Technical	No departures or relaxations, built to full 2+1 standard. On embankment for		

Blue Option Description – The Blue Option is a 4km route to the south of Caernarfon and is an alternative to the Pink and White Options for bypassing Llanwnda and Bontnewydd. The option begins at the A499/A487 roundabout, to the south of Llanwnda, running in a north easterly direction along the same alignment as the White Option for the first 850m. The route then runs in the same direction as the White Option but slightly further east of Llanwnda and Bontnewydd before deviating west and reconnecting with the A487 just north of Bontnewydd at a new roundabout. As with the White Option the road is on an embankment for the majority of its length with several structures required to pass over the same road and water courses as the White Option. The structures include two viaducts to pass over the Rivers Gwyrfai and Beuno.			
Appraisal Criteria	**Assessment**	**Distribution**	**Significance**
and operational feasibility:	approximately 90% of route. Maximum height of embankment is 19m. Substantial importation of construction material. Large structure required to cross Afon Gwyrfai and associated SSSI and SAC - significant structure for size of scheme and complex construction required. Access for construction limited. Welsh Highland Railway – likely some closure / possession required and highly skewed structure. Re-construction of Goat roundabout required.		
Financial affordability and deliverability:	30% increase in cost of structure to cross Afon Gwyrfai and associated SSSI and SAC due to complexity of construction. Very high cost per km (£15.9M/km).		
Risks:	Does not solve the wider transport implications of the area. Funding risks are known and manageable. Complex construction required. High risk from statutory objections. Flood modelling required at future stages.		
Comment:			

Brown Option

Brown Option Description – The Brown Option is a 10.4km route to the south east of Caernarfon. This route is not wholly offline and some part of it lies on the unclassified Caeathro / Pont Rug road which is referred to locally as the unofficial bypass.The Pink Option forms the first part of this route i.e. Llanwnda and Bontnewydd Bypass. From the A487 north of Bontnewydd this option runs north east to east for about 1.5km before linking into the unclassified road. The route continues online for about 2km until just past Felinbach the route deviates offline for about 1.8km before rejoining the unclassified road adjacent to Lon Glai Farm just south of the roundabout on the B4366. It remains online for about 0.4km before deviating offline and continuing north for about 0.8km connecting with the A487 at the Plas Menai roundabout. This end section follows a similar alignment to the Yellow Option.			
Appraisal Criteria	**Assessment**	**Distribution**	**Significance**
Economy			
Transport Economic Efficiency	Scheme Costs: £63.5M PVC: £72.3 PVB: £317.7M NPV: £245.4M BCR: 4.39	All road users to benefit from reduced journey times and vehicle operating costs The local economy will benefit.	Large Beneficial (+++) Slight Beneficial (+)
EALI (wider economic Impacts)	This option has the potential to open up development possibilities at new junction locations. The bypass may also act as a boundary to which development within Bontnewydd may encroach.	The local economy will benefit.	Slight Beneficial (+)
Environment			
Noise	Option 1.10 also results in traffic being diverted off the current A487 along which many NSRs currently occupy roadside positions. This results in significant traffic reductions along the current route. Again resulting in a significant number of NSRs will experience traffic noise reductions. A number of NSRs that currently experience very little traffic noise will experience small increases in traffic noise along the new route sections.	Bontnewydd & Caernarfon	Moderate Beneficial (++)
Local Air Quality	1291and 1123 properties will experience an increase in PM_{10} and NO_2 respectively. 1623 and 1791 properties will experience a decrease in PM_{10} and NO_2 respectively.	Benefits weighted to residents in less affluent areas of housing, adjacent to the existing A487(T) .	Moderate Beneficial (++)
Greenhouse Gas Emissions	CO_2 emissions – decrease of 759 tonnes in opening year. NPV of cost £1,608,000		Moderate Beneficial (++)
Landscape and townscape	Proposals include elements contradictory to existing topography and result in the loss of field patterns, boundaries and woodland. Introduction of engineered element into rural landscape affects both townscape character and visual context.	Welsh Highland Railway/ Afon Seiont crossings and Menai scarp cutting in particular.	Moderate Adverse (--)

Brown Option Description – The Brown Option is a 10.4km route to the south east of Caernarfon. This route is not wholly offline and some part of it lies on the unclassified Caeathro / Pont Rug road which is referred to locally as the unofficial bypass.The Pink Option forms the first part of this route i.e. Llanwnda and Bontnewydd Bypass. From the A487 north of Bontnewydd this option runs north east to east for about 1.5km before linking into the unclassified road. The route continues online for about 2km until just past Felinbach the route deviates offline for about 1.8km before rejoining the unclassified road adjacent to Lon Glai Farm just south of the roundabout on the B4366. It remains online for about 0.4km before deviating offline and continuing north for about 0.8km connecting with the A487 at the Plas Menai roundabout. This end section follows a similar alignment to the Yellow Option.

Appraisal Criteria	Assessment	Distribution	Significance
Bio-diversity	There is a crossing of the Afon Gwyrfai which is designated as a SAC and SSSI, this is the most important feature potentially impacted upon. In this location there are potential impacts upon Otter, fish species, habitats, bat feeding sites etc. At the location where the Afon Gwyrfai is crossed there is relatively limited riparian habitat however so the impact would be reduced, also it is understood that the road would pass over the river at height with no structures in the river therefore reducing impacts. Also of particular significance is the crossing of the Afon Seiont, this does not have statutory designation but it, and the surrounding habitats are designated as Wildlife Sites (non-statutory) and represent a good mosaic of valuable habitats as well as supporting many of the important protected species that are also present in the Afon Gwyrfai. The location where this option crosses the Afon Seiont has a potentially greater impact than the Purple or Yellow Option due to the more semi-natural form of the river and more extensive areas of woodland flanking the river at this location. Bats, Otters, Barn Owls, breeding birds, reptiles, fish and Brown Hare are all likely to be impacted upon. The impact is considered to be Moderate adverse where both the Afon Gwyrfai and Afon Seiont are being crossed (this could be downgraded by careful mitigation and programming of works). There will be slight/moderate adverse impacts where the Felinwnda, Pont Rug Wildlife Sites are impacted and also where the option passes close to certain areas of marshy grassland or impacts upon areas of semi-improved grassland. The impact upon otters is considered to be moderate/major and the impact upon bats is considered to be moderate with slight/moderate impacts upon breeding birds, fish and Badgers. The impacts are however generally slight adverse over much of the habitat to be impacted and other species. It is particularly recognised that significant parts of this option are on-line thus reducing impacts in comparison with the Purple and Yellow options.	The most significant potential impacts are focused upon the Afon Gwyrfai and Afon Seiont with valuable habitats and protected species concentrated in these areas. Potential impacts are generally much reduced over the majority of this option, although the impacts on protected species and particularly the widespread distribution of bats (especially Lesser Horseshoe Bats) needs particular consideration. The considerable on-line sections reduce the impacts (although many are at close proximity to Wildlife Sites).	Moderate Adverse (--)
Heritage	No physical impact on SAMs or Listed Buildings. One non-statutory archaeological sites subject to physical impact during road construction	Caernarfon / Bontnewydd Area	Moderate/Large Adverse

Brown Option Description – The Brown Option is a 10.4km route to the south east of Caernarfon. This route is not wholly offline and some part of it lies on the unclassified Caeathro / Pont Rug road which is referred to locally as the unofficial bypass.The Pink Option forms the first part of this route i.e. Llanwnda and Bontnewydd Bypass. From the A487 north of Bontnewydd this option runs north east to east for about 1.5km before linking into the unclassified road. The route continues online for about 2km until just past Felinbach the route deviates offline for about 1.8km before rejoining the unclassified road adjacent to Lon Glai Farm just south of the roundabout on the B4366. It remains online for about 0.4km before deviating offline and continuing north for about 0.8km connecting with the A487 at the Plas Menai roundabout. This end section follows a similar alignment to the Yellow Option.

Appraisal Criteria	Assessment	Distribution	Significance
	(buried section of Roman road). Very Large adverse impact on the historic setting of Caerlan Tibot SAM. Moderate adverse impact on the setting of Grade II Listed Bridge, Pont Rug. Slight adverse impact on the historic setting of two Grade II* and six Grade II Listed Buildings. Potential impact upon new (i.e. undiscovered) archaeological sites is unknown. However, the archaeological potential of the northernmost part of this route is high		(--/---)
Water environment	In general, the construction of new roadways through a 'greenfield' will increase surface water runoff, obstruct flood flow within the floodplain and cause a loss of flood plain storage if no mitigation measures are established. The crossing of the Afon Gwyrfai floodplain (via viaduct) will obstruct flood flow and cause a loss of flood storage and cannot be fully mitigated. Culverting 'main rivers' may also obstruct flood flow. General mitigation works include the attenuation of surface water runoff before discharging into watercourses, installing pollution control measures in high risk areas, crossing of watercourses to span the entire floodplain, and increasing culvert sizes at road crossings. The significance of effect has been determined for the design year and post-mitigation.	Afons Gwyrfai, Seiont, Cadnant and Rhyd.	Moderate Adverse (--)
Soils	The possible impact from the construction of embankments along the route		Moderate Adverse (--)
Society			
Transport safety	Number of accidents saved: 3,574 – 3,064 = 510 PVB = £172.2M – £152.2M = £20.0M As a single carriageway standard on an existing alignment there are few designated overtaking opportunities on this option. There are also many local accesses and side roads which connect to the highway. The 2+1 carriageway standard provides safe overtaking opportunities between A487/A499 Goat Rbt and A487 north of Bontnewydd.	All road users	Slight Beneficial (+)

Brown Option Description – The Brown Option is a 10.4km route to the south east of Caernarfon. This route is not wholly offline and some part of it lies on the unclassified Caeathro / Pont Rug road which is referred to locally as the unofficial bypass.The Pink Option forms the first part of this route i.e. Llanwnda and Bontnewydd Bypass. From the A487 north of Bontnewydd this option runs north east to east for about 1.5km before linking into the unclassified road. The route continues online for about 2km until just past Felinbach the route deviates offline for about 1.8km before rejoining the unclassified road adjacent to Lon Glai Farm just south of the roundabout on the B4366. It remains online for about 0.4km before deviating offline and continuing north for about 0.8km connecting with the A487 at the Plas Menai roundabout. This end section follows a similar alignment to the Yellow Option.

Appraisal Criteria	Assessment	Distribution	Significance
Personal security		General population throughout Bontnewydd, Dinas Caernarfon and surrounding settlements.	Neutral (0)
Permeability	The bypass will substantially reduce community severance within the settlements of Bontnewydd and Dinas (+++) by reducing predicted traffic flows (AADT). It would reduce severance to a lesser extent through Caernarfon (+). However, this relief from existing severance would be limited to the communities of Bontnewydd, Dinas and Caernarfon as other settlements, such as Caeathro, Waunfawr, Llanrug or Bethel would not experience any significant relief from severance (0). Major Beneficial overall (+++).	Relief from severance limited to communities of Bontnewydd, Dinas and Caernarfon.	Large Beneficial (+++)
Physical Fitness	The bypass does nothing directly to encourage active modes of transport within Bontnewydd, Dinas, Caernarfon or other nearby settlements. As it will reduce congestion through Bontnewydd and Dinas it may encourage more car use, however it may also encourage more travel by active modes such as walking and cycling (0). A total of 5 public rights of way will be severed by the proposal. Despite diversions being put in place, losses in amenity value of these routes may dissuade people from using them (-). Slight adverse overall (-).	General population throughout Bontnewydd, Dinas and Caernarfon and users of public rights of way.	Slight Adverse (-)
Social Inclusion	Although a full bypass solution, which includes the 'Pink Option' will have beneficial effects in terms of social inclusion, the substantial alignment configuration of the road, increases in junction number and the presence of local accesses onto the main road is unlikely to markedly increase accessibility contours and improve accessibly based upon criteria (+). Slight beneficial overall (+)	Populations west and south	Slight Beneficial (+)
Equality, Diversity & Human Rights	The Option is unlikely to have any impacts in relation to the race, ethnicity, colour or nationality, sex or marital status, disability: (physical, sensory or mental), age, religion or belief and sexual orientation (0). The provision of a new bypass does have the potential to encourage travel from non-Welsh speaking areas into this predominantly Welsh speaking area. This might lead to a dilution of the strong Welsh language culture within the area (-). Minor Adverse overall (-).	Potential impacts on strong Welsh language culture of the area.	Slight Adverse (-)

Brown Option Description – The Brown Option is a 10.4km route to the south east of Caernarfon. This route is not wholly offline and some part of it lies on the unclassified Caeathro / Pont Rug road which is referred to locally as the unofficial bypass.The Pink Option forms the first part of this route i.e. Llanwnda and Bontnewydd Bypass. From the A487 north of Bontnewydd this option runs north east to east for about 1.5km before linking into the unclassified road. The route continues online for about 2km until just past Felinbach the route deviates offline for about 1.8km before rejoining the unclassified road adjacent to Lon Glai Farm just south of the roundabout on the B4366. It remains online for about 0.4km before deviating offline and continuing north for about 0.8km connecting with the A487 at the Plas Menai roundabout. This end section follows a similar alignment to the Yellow Option.			
Appraisal Criteria	**Assessment**	**Distribution**	**Significance**
Transport Planning Objectives			
TPO 1	**Moderate Beneficial (++)** By 2016 journey time reduced by an average of 3 minutes throughout the day between Llanwnda and Plas Menai.		
TPO 2	**Moderate Beneficial (++)** By 2016 journey time reduced by an average of 4 minutes throughout the day respectively between Llanwnda and Caernarfon.		
TPO 3	**Moderate Beneficial (++)** By 2016 the number of vehicles through Dinas along the A487 reduces by 82% based on 24hr AADT flow. By 2016 the number of vehicles through Caernarfon along the A487 reduces by 20% based on 24hr AADT flow.		
TPO 4	**Large Beneficial (+++)** By 2016 accidents reduce by 46% along the A487. This meets the 22% reduction outlined in the TPOs.		
TPO 5	**Slight Beneficial (+)** Improved network resilience; by-pass provides a secondary route from between A487/A499 Goat Rbt and A487 north of Bontnewydd.		
Public acceptability:	Less acceptable to public in general as less future capacity and no connection to Cibyn. Perception does little for Caernarfon. Makes use of existing road corridor, however provides limited additional network capacity. Maintains existing network connections but no direct connection to Cibyn. No major CPO issues. Much of the route online therefore limited CPO, only over the offline sections. A total of 41 properties are affected by this option.		
Acceptability to other stakeholders:	Not acceptable to local councils affected (Dinas etc). Again perception does little for including Bethel and Pont-Rug. Less acceptable to Gwynedd as perception not an appropriate to upgrade to a trunk road. Consultation with EA on flooding of Gwyrfai – structure modified to suit. CCW consulted on SAC and SSSI issues. Western route acceptable. As mainly online improvement anticipate limited objections from other stakeholders. May need extra consultation with EA and CCW on large		

Brown Option Description – The Brown Option is a 10.4km route to the south east of Caernarfon. This route is not wholly offline and some part of it lies on the unclassified Caeathro / Pont Rug road which is referred to locally as the unofficial bypass.The Pink Option forms the first part of this route i.e. Llanwnda and Bontnewydd Bypass. From the A487 north of Bontnewydd this option runs north east to east for about 1.5km before linking into the unclassified road. The route continues online for about 2km until just past Felinbach the route deviates offline for about 1.8km before rejoining the unclassified road adjacent to Lon Glai Farm just south of the roundabout on the B4366. It remains online for about 0.4km before deviating offline and continuing north for about 0.8km connecting with the A487 at the Plas Menai roundabout. This end section follows a similar alignment to the Yellow Option.			
Appraisal Criteria	**Assessment**	**Distribution**	**Significance**
	structure at Pont-Rug.		
Technical and operational feasibility:	Two number relaxations in SSD but anticipated that the option could be built to full 2+1 and single CW standard. Flood relief structure – significant structure for size of scheme. Welsh Highland Railway – likely some closure / possession required. Deficit in E/W quantities. Disruption due to construction. Extensive private / side road accesses. Limited extra capacity, due to single c/w, reduced operational capacity and therefore less network resilience.		
Financial affordability and deliverability:	£6.08M/km. Cost relative to the level of improvement not as good as other options. Could be built in phases.		
Risks:	Funding risks are known and are manageable. Making existing unclassified highway into a trunk road. Flood modelling required at future stages.		
Comment:			

Brown Variant Option

Brown Variant Option Description – The Brown Variant Option is a 10.4km route to the south east of Caernarfon. This route is not wholly offline and some part of it lies on the unclassified Caeathro / Pont Rug road which is referred to locally as the unofficial bypass.The Pink Option (up to chainage 3,450m) forms the first part of this route i.e. Llanwnda and Bontnewydd Bypass. The Brown Variant Option is the same as the Brown Option, with the exception of the section between chainage 3,500m to 5,100m. From the A487 north of Bontnewydd this option runs north east to east for about 1.5km, impacting on the Gypsy Wood Park tourist attraction before linking into the unclassified road. The route continues online for about 2km until just past Felinbach the route deviates offline for about 1.8km before rejoining the unclassified road adjacent to Lon Glai Farm just south of the roundabout on the B4366. It remains online for about 0.4km before deviating offline and continuing north for about 0.8km connecting with the A487 at the Plas Menai roundabout. This end section follows a similar alignment to the Yellow Option.			
Appraisal Criteria	**Assessment**	**Distribution**	**Significance**
Economy			
Transport Economic Efficiency	Scheme Costs: £58.9M PVC: £67.8M PVB: £314.8M NPV: £247M BCR: 4.64	All road users to benefit from reduced journey times and vehicle operating costs The local economy will benefit.	Large Beneficial (+++)
EALI (wider economic Impacts)	This option has the potential to open up development possibilities at new junction locations. The bypass may also act as a boundary to which development within Bontnewydd may encroach.	The local economy will benefit.	Slight Beneficial (+)
Environment			
Noise	The Brown Option results in traffic being diverted off the current A487 through Bontnewydd along which many NSRs currently occupy roadside positions. This results in significant traffic reductions along the current A487 route. This is turn results in significant numbers of NSRs experiencing reductions in the associated traffic noise. Where the brown options new route is through predominantly rural areas, a number of NSRs that currently experience very little traffic noise will experience increases in road traffic noise along the new route. Overall, nearly 5000 NSRs will experience decreases in traffic related noise with approximately 600 NSRs experiencing increases in road traffic noise as a result of the scheme.	Bontnewydd, Caernarfon and the rural locations nearby the route of the 'unofficial A487 bypass'.	Moderate Beneficial (++)
Local Air Quality	1291and 1123 properties will experience an increase in PM_{10} and NO_2 respectively. 1623 and 1791 properties will experience a decrease in PM_{10} and NO_2	Benefits weighted to residents in less affluent areas of housing, adjacent to the	Moderate Beneficial (++)

Brown Variant Option Description – The Brown Variant Option is a 10.4km route to the south east of Caernarfon. This route is not wholly offline and some part of it lies on the unclassified Caeathro / Pont Rug road which is referred to locally as the unofficial bypass.The Pink Option (up to chainage 3,450m) forms the first part of this route i.e. Llanwnda and Bontnewydd Bypass. The Brown Variant Option is the same as the Brown Option, with the exception of the section between chainage 3,500m to 5,100m. From the A487 north of Bontnewydd this option runs north east to east for about 1.5km, impacting on the Gypsy Wood Park tourist attraction before linking into the unclassified road. The route continues online for about 2km until just past Felinbach the route deviates offline for about 1.8km before rejoining the unclassified road adjacent to Lon Glai Farm just south of the roundabout on the B4366. It remains online for about 0.4km before deviating offline and continuing north for about 0.8km connecting with the A487 at the Plas Menai roundabout. This end section follows a similar alignment to the Yellow Option.

Appraisal Criteria	Assessment	Distribution	Significance
	respectively.	existing A487(T) . Assessment refers to entire study area from Llanwnda to Felinheli.	
Greenhouse Gas Emissions	CO_2 emissions – decrease of 778 tonnes in opening year. NPV of cost £1,611,000		Moderate Beneficial (++)
Landscape and townscape	Proposals include elements contradictory to existing topography and result in the loss of field patterns, boundaries and woodland. Introduction of engineered element into rural landscape affects both landscape and townscape character and visual context.	Welsh Highland Railway/ Afon Seiont crossings and Menai scarp cutting in particular.	Moderate Adverse (--)
Bio-diversity	There is a crossing of the Afon Gwyrfai which is designated as a SAC and SSSI, this is the most important feature potentially impacted upon. In this location there are potential impacts upon Otter, fish species, habitats, bat feeding sites etc. At the location where the Afon Gwyrfai is crossed there is relatively limited riparian habitat however so the impact would be reduced, also it is understood that the road would pass over the river at height with no structures in the river therefore reducing impacts. Also of particular significance is the crossing of the Afon Seiont, this does not have statutory designation but it, and the surrounding habitats are designated as Wildlife Sites (non-statutory) and represent a good mosaic of valuable habitats as well as supporting many of the important protected species that are also present in the Afon Gwyrfai. The location where this option crosses the Afon Seiont has a potentially greater impact than the Purple and Yellow and to a lesser extent the Black and Orange Option due to the more semi-natural form of the river and more extensive areas of woodland flanking the river at this location. Bats, Otters, Barn Owls, breeding birds, reptiles, amphibians, fish and Brown Hare are all likely to be impacted upon. The impact is considered to be Moderate adverse where both the Afon Gwyrfai and Afon Seiont are being crossed (this could be downgraded by	The most significant potential impacts are focused upon the Afon Gwyrfai and Afon Seiont with valuable habitats and protected species concentrated in these areas. Potential impacts are generally much reduced over the majority of this option, although the impacts on Wildlife Sites and protected species, and particularly the widespread distribution of bats (especially Lesser Horseshoe Bats) needs particular consideration. The considerable on-line sections reduce the impacts (although many are at close proximity to Wildlife Sites).	Moderate Adverse (--)

Brown Variant Option Description – The Brown Variant Option is a 10.4km route to the south east of Caernarfon. This route is not wholly offline and some part of it lies on the unclassified Caeathro / Pont Rug road which is referred to locally as the unofficial bypass.The Pink Option (up to chainage 3,450m) forms the first part of this route i.e. Llanwnda and Bontnewydd Bypass. The Brown Variant Option is the same as the Brown Option, with the exception of the section between chainage 3,500m to 5,100m. From the A487 north of Bontnewydd this option runs north east to east for about 1.5km, impacting on the Gypsy Wood Park tourist attraction before linking into the unclassified road. The route continues online for about 2km until just past Felinbach the route deviates offline for about 1.8km before rejoining the unclassified road adjacent to Lon Glai Farm just south of the roundabout on the B4366. It remains online for about 0.4km before deviating offline and continuing north for about 0.8km connecting with the A487 at the Plas Menai roundabout. This end section follows a similar alignment to the Yellow Option.			
Appraisal Criteria	**Assessment**	**Distribution**	**Significance**
	careful mitigation and programming of works). There will be slight/moderate adverse impacts where the Afon Beuno, Maes Merddin, Felinwnda, Pont Rug Wildlife Sites are impacted and also where the option passes close to certain areas of marshy grassland or impacts upon areas of semi-improved grassland. The impact upon otters is considered to be moderate/major and the impact upon bats is considered to be moderate with slight/moderate impacts upon breeding birds, fish and Badgers. The impacts are however generally slight adverse over much of the habitat to be impacted and other species. It is particularly recognised that significant parts of this option are on-line thus reducing impacts in comparison with the Purple and Yellow and to a lesser extent Black and Orange Options.		
Heritage	No physical impact on SAMs or Listed Buildings. One non-statutory archaeological sites subject to physical impact during road construction (buried section of Roman road). Very Large adverse impact on the historic setting of Caerlan Tibot SAM. Moderate adverse impact on the setting of Grade II Listed Bridge, Pont Rug. Slight adverse impact on the historic setting of two Grade II* and six Grade II Listed Buildings. Potential impact upon new (i.e. undiscovered) archaeological sites is unknown. However, the archaeological potential of the northernmost part of this route is high	Caernarfon / Bontnewydd Area	Moderate/Large Adverse (--/---)
Water environment	In general, the construction of new roadways through a 'greenfield' will increase surface water runoff, obstruct flood flow within the floodplain and cause a loss of flood plain storage if no mitigation measures are established. Culverting 'main rivers' may obstruct flood flow and the crossing of the Afon Gwyrfai floodplain (via viaduct) will obstruct flood flow, cause a loss of flood storage and cannot be fully mitigated. Therefore, this option has an overall assessment score of 'Moderate Adverse Impacts'. General mitigation works include the attenuation of surface water runoff before	All watercourses along the Brown Option corridor, including Afons Beuno, Seiont, Gwyrfai, Rhyd and unnamed tributary of the Plas Menai.	Moderate Adverse (--)

Brown Variant Option Description – The Brown Variant Option is a 10.4km route to the south east of Caernarfon. This route is not wholly offline and some part of it lies on the unclassified Caeathro / Pont Rug road which is referred to locally as the unofficial bypass.The Pink Option (up to chainage 3,450m) forms the first part of this route i.e. Llanwnda and Bontnewydd Bypass. The Brown Variant Option is the same as the Brown Option, with the exception of the section between chainage 3,500m to 5,100m. From the A487 north of Bontnewydd this option runs north east to east for about 1.5km, impacting on the Gypsy Wood Park tourist attraction before linking into the unclassified road. The route continues online for about 2km until just past Felinbach the route deviates offline for about 1.8km before rejoining the unclassified road adjacent to Lon Glai Farm just south of the roundabout on the B4366. It remains online for about 0.4km before deviating offline and continuing north for about 0.8km connecting with the A487 at the Plas Menai roundabout. This end section follows a similar alignment to the Yellow Option.

Appraisal Criteria	Assessment	Distribution	Significance
	discharging into watercourses, installing pollution control measures in high risk areas, crossing of watercourses to span the entire floodplain, and increasing culvert sizes at road crossings. The significance of effect has been determined for the design year and post-mitigation.		
Soils	The possible impacts from the construction of embankments along the route.		Moderate Adverse (--)
Society			
Transport safety	Number of accidents saved: 3,574 – 3,176 = 398 PVB = £172.2M – £157.5M = £14.7M As a single carriageway standard on an existing alignment there are few designated overtaking opportunities on this option. There are also many local accesses and side roads which connect to the highway. The 2+1 carriageway standard provides safe overtaking opportunities between A487/A499 Goat Rbt and A487 north of Bontnewydd.	All road users	Slight Beneficial (+)
Personal security		General population throughout Bontnewydd, Dinas Caernarfon and surrounding settlements.	Neutral (0)
Permeability	The bypass will substantially reduce community severance within the settlements of Bontnewydd and Dinas (+++) by reducing predicted traffic flows (AADT). It would reduce severance to a lesser extent through Caernarfon (+). However, this relief from existing severance would be limited to the communities of Bontnewydd, Dinas and Caernarfon as other settlements, such as Caeathro, Waunfawr, Llanrug or Bethel would not experience any significant relief from severance (0). Major Beneficial overall (+++).	Relief from severance limited to communities of Bontnewydd, Dinas and Caernarfon.	Large Beneficial (+++)
Physical Fitness	Without direct provision for cyclist and pedestrians, the bypass does nothing directly to encourage active modes of transport within Bontnewydd, Dinas or Caernarfon (0). A total of 6 public rights of way will be severed by the	General population throughout Bontnewydd, Dinas and Caernarfon and users of public	Slight Adverse (-)

Brown Variant Option Description – The Brown Variant Option is a 10.4km route to the south east of Caernarfon. This route is not wholly offline and some part of it lies on the unclassified Caeathro / Pont Rug road which is referred to locally as the unofficial bypass.The Pink Option (up to chainage 3,450m) forms the first part of this route i.e. Llanwnda and Bontnewydd Bypass. The Brown Variant Option is the same as the Brown Option, with the exception of the section between chainage 3,500m to 5,100m. From the A487 north of Bontnewydd this option runs north east to east for about 1.5km, impacting on the Gypsy Wood Park tourist attraction before linking into the unclassified road. The route continues online for about 2km until just past Felinbach the route deviates offline for about 1.8km before rejoining the unclassified road adjacent to Lon Glai Farm just south of the roundabout on the B4366. It remains online for about 0.4km before deviating offline and continuing north for about 0.8km connecting with the A487 at the Plas Menai roundabout. This end section follows a similar alignment to the Yellow Option.			
Appraisal Criteria	**Assessment**	**Distribution**	**Significance**
	proposal. Despite diversions being put in place, losses in amenity value of these routes may dissuade people from using them (-). Slight adverse overall (-).	rights of way.	
Social Inclusion	Although a full bypass solution, which includes the 'Pink Option' will have beneficial effects in terms of social inclusion, the substantial alignment configuration of the road, increases in junction number and the presence of local accesses onto the main road is unlikely to markedly increase accessibility contours and improve accessibly based upon criteria (+). Slight beneficial overall (+)	Populations west and south	Slight Beneficial (+)
Equality, Diversity & Human Rights	The Option is unlikely to have any impacts in relation to the race, ethnicity, colour or nationality, sex or marital status, disability: (physical, sensory or mental), age, religion or belief and sexual orientation (0). The provision of a new bypass does have the potential to encourage travel from non-Welsh speaking areas into this predominantly Welsh speaking area. This might lead to a dilution of the strong Welsh language culture within the area (-). Slight Adverse overall (-).	Potential impacts on strong Welsh language culture of the area.	Slight Adverse (-)
Transport Planning Objectives			
TPO 1	Moderate Beneficial (++) By 2016 journey time reduced by an average of 4 minutes throughout the day between Llanwnda and Plas Menai.		
TPO 2	Moderate Beneficial (++) By 2016 journey time reduced by an average of 4 minutes throughout the day between Llanwnda and Caernarfon.		
TPO 3	Moderate Beneficial (++) By 2016 the number of vehicles through Dinas along the A487 reduces by 82% based on 24hr AADT flow. By 2016 the number of vehicles through Caernarfon along the A487 reduces by 21% based on 24hr AADT flow.		
TPO 4	Large Beneficial (+++) By 2016 accidents reduce by 47% along the A487. This meets the 22% reduction outlined in the TPOs.		

Brown Variant Option Description – The Brown Variant Option is a 10.4km route to the south east of Caernarfon. This route is not wholly offline and some part of it lies on the unclassified Caeathro / Pont Rug road which is referred to locally as the unofficial bypass.The Pink Option (up to chainage 3,450m) forms the first part of this route i.e. Llanwnda and Bontnewydd Bypass. The Brown Variant Option is the same as the Brown Option, with the exception of the section between chainage 3,500m to 5,100m. From the A487 north of Bontnewydd this option runs north east to east for about 1.5km, impacting on the Gypsy Wood Park tourist attraction before linking into the unclassified road. The route continues online for about 2km until just past Felinbach the route deviates offline for about 1.8km before rejoining the unclassified road adjacent to Lon Glai Farm just south of the roundabout on the B4366. It remains online for about 0.4km before deviating offline and continuing north for about 0.8km connecting with the A487 at the Plas Menai roundabout. This end section follows a similar alignment to the Yellow Option.

Appraisal Criteria	Assessment	Distribution	Significance
TPO 5	Slight Beneficial (+) Improved network resilience; by-pass provides a secondary route from between A487/A499 Goat Rbt and A487 north of Bontnewydd.		
Public acceptability:	Less acceptable to public in general as less future capacity and no connection to Cibyn. Perception does little for Caernarfon. Makes use of existing road corridor, however provides limited additional network capacity. Maintains existing network connections but no direct connection to Cibyn. No major CPO issues. Much of the route online therefore limited CPO, only over the offline sections. A total of 44 properties are affected by this option. Significant impact on Gypsy Wood.		
Acceptability to other stakeholders:	Not acceptable to local councils affected (Dinas etc). Again perception does little for including Bethel and Pont-Rug. Less acceptable to Gwynedd as perception not an appropriate to upgrade to a trunk road. Consultation with EA on flooding of Gwyrfai – structure modified to suit. CCW consulted on SAC and SSSI issues. Western route acceptable. As mainly online improvement anticipate limited objections from other stakeholders. May need extra consultation with EA and CCW on large structure at Pont-Rug.		
Technical and operational feasibility:	Two number departures in SSD but anticipated that it could be designed and built to full 2+1 and single CW standard. Flood relief structure over Gwyrfai – significant structure for size of scheme. Welsh Highland Railway – likely some closure / possession required. Deficit in earthwork quantities. Disruption due to construction more significant than bypass options due to use of existing highway. Extensive private / side road accesses. Limited future capacity, due to single c/w, reduced operational capacity and therefore less network resilience, reflected in score for TPO 5.		
Financial affordability and deliverability:	£5.7M/km. Cost relative to the level of improvement not as good as other options. Could be built in phases.		

Brown Variant Option Description – The Brown Variant Option is a 10.4km route to the south east of Caernarfon. This route is not wholly offline and some part of it lies on the unclassified Caeathro / Pont Rug road which is referred to locally as the unofficial bypass.The Pink Option (up to chainage 3,450m) forms the first part of this route i.e. Llanwnda and Bontnewydd Bypass. The Brown Variant Option is the same as the Brown Option, with the exception of the section between chainage 3,500m to 5,100m. From the A487 north of Bontnewydd this option runs north east to east for about 1.5km, impacting on the Gypsy Wood Park tourist attraction before linking into the unclassified road. The route continues online for about 2km until just past Felinbach the route deviates offline for about 1.8km before rejoining the unclassified road adjacent to Lon Glai Farm just south of the roundabout on the B4366. It remains online for about 0.4km before deviating offline and continuing north for about 0.8km connecting with the A487 at the Plas Menai roundabout. This end section follows a similar alignment to the Yellow Option.

Appraisal Criteria	**Assessment**	**Distribution**	**Significance**
Risks:	Funding risks are known and are manageable. Making existing unclassified highway into a trunk road. Flood modelling required at future stages.		
Comment:			

Purple Option

Purple Option Description – The Purple Option is an 11km route to the south east of Caernarfon. This option is shown on Figures 15a-g. The Pink Option forms the first part of this route i.e. Llanwnda and Bontnewydd Bypass. From the A487 this route option runs northeast and to the east of Caernarfon, lying south of Caernarfon Quarry, north of Glan Gwna Holiday Park and south of Cibyn Industrial Estate before connecting with the A4086 at a new roundabout. It then continues in a north east direction crossing over the B4366 to the north west of Bethel and connects with the A487, east of Caernarfon in a non-standard form of grade separated junction at the Felinheli Bypass. The first 6.5km section of this route to the B4366 is common to the Yellow Option. On leaving the A487 the road is on embankment to chainage 4,050m at Penybryn Road which it crosses by way of a box culvert. The road then enters a small cutting before approaching the Afon Seiont floodplain on embankment and crossing on a large viaduct. The road lies to the north of the caravan/holiday park and is in cutting until the A4086. The road is at grade for a short distance before entering another cutting, which allows a minor road to cross on an overbridge. It then rises on embankment over the B4366 which is accommodated with an underbridge. On the approach to the A487, the road is in cutting and is crossed by two overbridges. The first is to accommodate a private means of access and the second is for the A487 slip road.

Appraisal Criteria	Assessment	Distribution	Significance
Economy			
Transport Economic Efficiency	Scheme Costs: £85.8M PVC: £97.5M PVB: £420.2M NPV: £322.8M BCR: 4.31	All road users to benefit from reduced journey times and vehicle operating costs	Large Beneficial (+++)
EALI (wider economic Impacts)	This option has the potential to open up development possibilities at junction locations, including the Cibyn Industrial Estate. The bypass may also act as a boundary to which development may encroach. This alignment will also impact upon the existing Glan Gwna holiday park. Disbenefit to north of Caernarfon as no connection to Plas Menai.	The local economy will benefit although disbenefit to businesses on old route.	Moderate Beneficial (++)
Environment			
Noise	The Purple Option results in traffic being diverted off the current A487 along which many Noise Sensitive Receptors (NSR) currently occupy roadside positions. This results in significant traffic reductions along the current route. A significant number of NSRs will therefore experience traffic noise reductions. A number of NSRs that currently experience very little traffic noise will experience small increases in traffic noise along the new route sections.	Bontnewydd & Caernarfon	Moderate Beneficial (++)
Local Air Quality	237 and 69 properties will experience an increase in PM_{10} and NO_2 respectively. 2660 and 2828 properties will experience a decrease in PM_{10} and NO_2 respectively.	Benefits weighted to residents in less affluent areas of housing, adjacent to the existing A487(T)	Moderate Beneficial (++)

Purple Option Description – The Purple Option is an 11km route to the south east of Caernarfon. This option is shown on Figures 15a-g. The Pink Option forms the first part of this route i.e. Llanwnda and Bontnewydd Bypass. From the A487 this route option runs northeast and to the east of Caernarfon, lying south of Caernarfon Quarry, north of Glan Gwna Holiday Park and south of Cibyn Industrial Estate before connecting with the A4086 at a new roundabout. It then continues in a north east direction crossing over the B4366 to the north west of Bethel and connects with the A487, east of Caernarfon in a non-standard form of grade separated junction at the Felinheli Bypass. The first 6.5km section of this route to the B4366 is common to the Yellow Option. On leaving the A487 the road is on embankment to chainage 4,050m at Penybryn Road which it crosses by way of a box culvert. The road then enters a small cutting before approaching the Afon Seiont floodplain on embankment and crossing on a large viaduct. The road lies to the north of the caravan/holiday park and is in cutting until the A4086. The road is at grade for a short distance before entering another cutting, which allows a minor road to cross on an overbridge. It then rises on embankment over the B4366 which is accommodated with an underbridge. On the approach to the A487, the road is in cutting and is crossed by two overbridges. The first is to accommodate a private means of access and the second is for the A487 slip road.

Appraisal Criteria	Assessment	Distribution	Significance
Greenhouse Gas Emissions	CO_2 emissions – decrease of 1,017 tonnes in opening year. NPV of cost £2,358,000		Moderate Beneficial (++)
Landscape and townscape	Proposals include elements contradictory to existing topography and result in the loss of field patterns, boundaries and woodland. Introduction of engineered element into rural landscape affects both townscape character and visual context.	Welsh Highland Railway and Afon Seiont crossings in particular	Moderate Adverse (--)
Bio-diversity	There is a crossing of the Afon Gwyrfai which is designated as a SAC and SSSI, this is the most important feature potentially impacted upon. In this location there are potential impacts upon Otter, fish species, habitats, bat feeding sites etc.. At the location where the Afon Gwyrfai is crossed there is relatively limited riparian habitat however so the impact would be reduced, also it is understood that the road would pass over the river at height with no structures in the river therefore reducing impacts. Also of particular significance is the crossing of the Afon Seiont, this does not have statutory designation but it, and the surrounding habitats are designated as Wildlife Sites (non-statutory) and represent a good mosaic of valuable habitats as well as supporting many of the important protected species that are also present in the Afon Gwyrfai. Bats, Otters, Barn Owls, breeding birds, reptiles, fish and Brown Hare are all likely to be impacted upon with breeding birds and Brown Hare possibly more so than any of the other options. The impact is considered to be Moderate adverse and Slight/moderate adverse where the Afon Gwyrfai and Afon Seiont respectively are being crossed (this could be downgraded by careful mitigation and programming of works). There will be slight/moderate adverse impacts where the Felinwnda, Waenfawr Road and Afon Seiont Mosaic (North) Wildlife Sites are impacted and also where the option passes close to certain areas of marshy grassland or impacts upon areas of semi-improved grassland. The impact upon bats, otters and Brown	The most significant potential impacts are focused upon the Afon Gwyrfai and Afon Seiont with valuable habitats and protected species concentrated within these areas. Potential impacts are generally much reduced over the majority of this option, although the impacts on a number of protected species and particularly the widespread distribution of bats (especially Lesser Horseshoe Bats) needs particular consideration.	Moderate Adverse (--)

Purple Option Description – The Purple Option is an 11km route to the south east of Caernarfon. This option is shown on Figures 15a-g. The Pink Option forms the first part of this route i.e. Llanwnda and Bontnewydd Bypass. From the A487 this route option runs northeast and to the east of Caernarfon, lying south of Caernarfon Quarry, north of Glan Gwna Holiday Park and south of Cibyn Industrial Estate before connecting with the A4086 at a new roundabout. It then continues in a north east direction crossing over the B4366 to the north west of Bethel and connects with the A487, east of Caernarfon in a non-standard form of grade separated junction at the Felinheli Bypass. The first 6.5km section of this route to the B4366 is common to the Yellow Option. On leaving the A487 the road is on embankment to chainage 4,050m at Penybryn Road which it crosses by way of a box culvert. The road then enters a small cutting before approaching the Afon Seiont floodplain on embankment and crossing on a large viaduct. The road lies to the north of the caravan/holiday park and is in cutting until the A4086. The road is at grade for a short distance before entering another cutting, which allows a minor road to cross on an overbridge. It then rises on embankment over the B4366 which is accommodated with an underbridge. On the approach to the A487, the road is in cutting and is crossed by two overbridges. The first is to accommodate a private means of access and the second is for the A487 slip road.

Appraisal Criteria	Assessment	Distribution	Significance
	Hare is considered to be moderate with slight/moderate impacts upon breeding birds, reptiles, fish and Badgers. The impacts are however generally slight adverse over much of the habitat to be impacted and other species.		
Heritage	No physical impact on SAMs. One Grade II Listed milestone requiring relocation. Two non-statutory archaeological sites subject to physical impact during road construction (buried section of Roman road, and Post-Medieval trackway). Moderate adverse impact on the historic setting of three SAMs and five Grade II Listed Buildings Potential impact upon new (i.e. undiscovered) archaeological sites is unknown	Caernarfon / Bontnewydd Area	Slight/Moderate Adverse (-/--)
Water environment	In general, the construction of new roadways through a 'greenfield' will increase surface water runoff, obstruct flood flow within the floodplain and cause a loss of flood plain storage if no mitigation measures are established. The crossing of the Afon Gwyrfai floodplain (via viaduct) will obstruct flood flow and cause a loss of flood storage and cannot be fully mitigated. Culverting 'main rivers' may also obstruct flood flow. General mitigation works include the attenuation of surface water runoff before discharging into watercourses, installing pollution control measures in high risk areas, crossing of watercourses to span the entire floodplain, and increasing culvert sizes at road crossings. The significance of effect has been determined for the design year and post-mitigation.	Afons Gwyrfai, Seiont, Cadnant and Rhyd.	Moderate Adverse (--)
Soils	The possible impact on the mineral resources at Caernarfon Quarry.	Caernarfon Seiont Quarry	Moderate Adverse (--)
Society			
Transport safety	Number of accidents saved: 3,574 – 2,675 = 899 PVB = £172.2M - £136.1M = £36.1M The 2+1 carriageway standard provides safe overtaking opportunities.	All road users	Large Beneficial (+++)

Purple Option Description – The Purple Option is an 11km route to the south east of Caernarfon. This option is shown on Figures 15a-g. The Pink Option forms the first part of this route i.e. Llanwnda and Bontnewydd Bypass. From the A487 this route option runs northeast and to the east of Caernarfon, lying south of Caernarfon Quarry, north of Glan Gwna Holiday Park and south of Cibyn Industrial Estate before connecting with the A4086 at a new roundabout. It then continues in a north east direction crossing over the B4366 to the north west of Bethel and connects with the A487, east of Caernarfon in a non-standard form of grade separated junction at the Felinheli Bypass. The first 6.5km section of this route to the B4366 is common to the Yellow Option. On leaving the A487 the road is on embankment to chainage 4,050m at Penybryn Road which it crosses by way of a box culvert. The road then enters a small cutting before approaching the Afon Seiont floodplain on embankment and crossing on a large viaduct. The road lies to the north of the caravan/holiday park and is in cutting until the A4086. The road is at grade for a short distance before entering another cutting, which allows a minor road to cross on an overbridge. It then rises on embankment over the B4366 which is accommodated with an underbridge. On the approach to the A487, the road is in cutting and is crossed by two overbridges. The first is to accommodate a private means of access and the second is for the A487 slip road.

Appraisal Criteria	Assessment	Distribution	Significance
Personal security		General population throughout Bontnewydd, Dinas Caernarfon and surrounding settlements.	Neutral (0)
Permeability	The bypass will substantially reduce community severance within the settlements of Bontnewydd and Dinas (+++) by reducing predicted traffic flows (AADT). It would also reduce severance to a lesser extent through Caernarfon (++). However, this relief from existing severance would be limited to the communities of Bontnewydd, Dinas and Caernarfon as other settlements, such as Caeathro, Waunfawr, Llanrug or Bethal would not experience any significant relief from severance (0). Major Beneficial overall (+++).	Relief from severance limited to communities of Bontnewydd, Dinas and Caernarfon.	Large Beneficial (+++)
Physical Fitness	The bypass does nothing directly to encourage active modes of transport within Bontnewydd, Dinas, Caernarfon or other nearby settlements. As it will reduce congestion through Bontnewydd and Dinas it may encourage more car use, however it may also encourage more travel by active modes such as walking and cycling (0). A total of 11 public rights of way will be severed by the proposal. Despite diversions being put in place losses in amenity value of these routes may dissuade people from using them (-). Slight adverse overall (-).	General population throughout Bontnewydd, Dinas and Caernarfon and users of public rights of way.	Slight Adverse (-)
Social Inclusion	Full bypass option of all communities further benefits journey times to populations west and south and increases accessibility contours. Moderate Beneficial overall (++).	Populations to the west and south	Moderate Beneficial (++)
Equality, Diversity & Human Rights	The Option is unlikely to have any impacts in relation to the race, ethnicity, colour or nationality, sex or marital status, disability: (physical, sensory or mental), age, religion or belief and sexual orientation (0). The provision of a new bypass does have the potential to encourage travel from non-Welsh speaking areas into this predominantly Welsh speaking area. This might lead to a dilution of the strong Welsh language culture within the area (-). Slight Adverse overall (-)	Potential impacts on strong Welsh language culture of the area.	Slight Adverse (-)

Purple Option Description – The Purple Option is an 11km route to the south east of Caernarfon. This option is shown on Figures 15a-g. The Pink Option forms the first part of this route i.e. Llanwnda and Bontnewydd Bypass. From the A487 this route option runs northeast and to the east of Caernarfon, lying south of Caernarfon Quarry, north of Glan Gwna Holiday Park and south of Cibyn Industrial Estate before connecting with the A4086 at a new roundabout. It then continues in a north east direction crossing over the B4366 to the north west of Bethel and connects with the A487, east of Caernarfon in a non-standard form of grade separated junction at the Felinheli Bypass. The first 6.5km section of this route to the B4366 is common to the Yellow Option. On leaving the A487 the road is on embankment to chainage 4,050m at Penybryn Road which it crosses by way of a box culvert. The road then enters a small cutting before approaching the Afon Seiont floodplain on embankment and crossing on a large viaduct. The road lies to the north of the caravan/holiday park and is in cutting until the A4086. The road is at grade for a short distance before entering another cutting, which allows a minor road to cross on an overbridge. It then rises on embankment over the B4366 which is accommodated with an underbridge. On the approach to the A487, the road is in cutting and is crossed by two overbridges. The first is to accommodate a private means of access and the second is for the A487 slip road.

Appraisal Criteria	Assessment	Distribution	Significance
Transport Planning Objectives			
TPO 1	**Moderate Beneficial (++)** By 2016 journey time reduced by an average of 5 minutes throughout the day between Llanwnda and Plas Menai.		
TPO 2	**Moderate Beneficial (++)** By 2016 journey time reduced by an average of 4 minutes throughout the day between Llanwnda and Caernarfon.		
TPO 3	**Large Beneficial (+++)** By 2016 the number of vehicles through Dinas along the A487 reduces by 79% based on 24hr AADT flow. By 2016 the number of vehicles through Caernarfon along the A487 reduces by 29% based on 24hr AADT flow.		
TPO 4	**Large Beneficial (+++)** By 2016 accidents reduce by 60% along the A487. This meets the 22% reduction outlined in the TPOs.		
TPO 5	**Large Beneficial (+++)** Improved network resilience; by-pass provides a secondary route from north to south.		
Public acceptability:	Acceptable. Has wide benefits for communities of Bontnewydd, Dinas, Caernarfon and Bethel. A strategic link which would benefit wider public to a greater extent. Locally provides few connections but does connect to Cibyn Industrial Estate. CPO required across entire route but specifically across Caernarfon Quarry and Glan Gwna Caravan Park.		
Acceptability to other stakeholders:	Acceptable to wider councils, within the study area. Consultation with EA held over the River Seiont / Glan Gwna structure to consider flood capacity. Consultation undertaken with CCW to minimise environmental risks. Acceptable to Gwynedd Council. Consultation with EA on flooding of Gwyrfai – structure modified to suit. CCW consulted on SAC and SSSI issues. Western route of Bontnewydd acceptable.		

Purple Option Description – The Purple Option is an 11km route to the south east of Caernarfon. This option is shown on Figures 15a-g. The Pink Option forms the first part of this route i.e. Llanwnda and Bontnewydd Bypass. From the A487 this route option runs northeast and to the east of Caernarfon, lying south of Caernarfon Quarry, north of Glan Gwna Holiday Park and south of Cibyn Industrial Estate before connecting with the A4086 at a new roundabout. It then continues in a north east direction crossing over the B4366 to the north west of Bethel and connects with the A487, east of Caernarfon in a non-standard form of grade separated junction at the Felinheli Bypass. The first 6.5km section of this route to the B4366 is common to the Yellow Option. On leaving the A487 the road is on embankment to chainage 4,050m at Penybryn Road which it crosses by way of a box culvert. The road then enters a small cutting before approaching the Afon Seiont floodplain on embankment and crossing on a large viaduct. The road lies to the north of the caravan/holiday park and is in cutting until the A4086. The road is at grade for a short distance before entering another cutting, which allows a minor road to cross on an overbridge. It then rises on embankment over the B4366 which is accommodated with an underbridge. On the approach to the A487, the road is in cutting and is crossed by two overbridges. The first is to accommodate a private means of access and the second is for the A487 slip road.

Appraisal Criteria	**Assessment**	**Distribution**	**Significance**
Technical and operational feasibility:	At present some relaxations in SSD and Felinheli free-flow will require several departures. Otherwise built to full 2+1 standard. Flood relief structure – significant structure for size of scheme. Welsh Highland Railway – likely some closure / possession required. Large structure at Glan Gwna. Felinheli tie-in, complex arrangement incorporating E/W, structures and existing A487. Disruption due to construction.		
Financial affordability and deliverability:	£7.9M/km. Consultation held with DVO regarding larger areas of compensation.	Could be built in phases.	
Risks:	Design and CPO across the quarry. Design issues at Felinheli tie in. Funding risks are known and are manageable. Flood modelling required at future stages.		
Comment:			

Yellow Option

Yellow Option Description – This is effectively the same as the Purple Option except for the section of the route beyond chainage 8,000m. Instead of tying into the A487 at the Felinheli Bypass the route deviates north and links into the A487 at the Plas Menai roundabout. This results in a shorter route by up to 1km. On this section there is a high embankment of up to 9m as the route crosses the B4366 and on the approach to the A487 there is a long steep gradient of 5% which is within a cutting of up to 22m in depth.
Extent of WS2+1 carriageway. This route is made up of three sections of WS2+1 standard carriageway connected by roundabouts as follows:
Section 1 chainage 0 – 3,450 (Pink Option)
Section 2 chainage 3,450 – 6,500 (A487 to A4086 adjacent to Cibyn Industrial Estate)
Section 3 chainage 6,500 – 10,900 (A4086 to A487 at Plas Menai roundabout)
The extent WS2+1 carriageway for the Pink Option is as previously described. The other sections are as follows;

Appraisal Criteria	Assessment	Distribution	Significance
Economy			
Transport Economic Efficiency	Scheme Costs: £77.3M PVC: £87.5M PVB: £415.8M NPV: £328.3M BCR: 4.75	All road users to benefit from reduced journey times and vehicle operating costs The local economy will benefit although disbenefit to businesses on old route.	Large Beneficial (+++) Moderate Beneficial (++)
EALI (wider economic Impacts)	This option has the potential to open up development possibilities at junction locations, including the Cibyn Industrial Estate. The bypass may also act as a boundary to which development may encroach. This alignment will also impact upon the existing Glan Gwna holiday park.	The local economy will benefit although disbenefit to businesses on old route.	Moderate Beneficial (++)
Environment			
Noise	The Yellow Option also results in traffic being diverted off the current A487 along which many NSRs currently occupy roadside positions. This results in significant traffic reductions along the current route. Again resulting in a significant number of NSRs will experience traffic noise reductions. A number of NSRs that currently experience very little traffic noise will experience small increases in traffic noise along the new route sections.	Bontnewydd & Caernarfon	Moderate Beneficial (++)
Local Air Quality	220 and 57 properties will experience an increase in PM_{10} and NO_2 respectively. 2660 and 2823 properties will experience a decrease in PM_{10} and NO_2 respectively.	Benefits weighted to residents in less affluent areas of housing, adjacent to the existing A487(T) .	Moderate Beneficial (++)
Greenhouse Gas Emissions	CO_2 emissions – decrease of 935 tonnes in opening year. NPV of cost £2,138,000		Moderate Beneficial (++)

Yellow Option Description – This is effectively the same as the Purple Option except for the section of the route beyond chainage 8,000m. Instead of tying into the A487 at the Felinheli Bypass the route deviates north and links into the A487 at the Plas Menai roundabout. This results in a shorter route by up to 1km. On this section there is a high embankment of up to 9m as the route crosses the B4366 and on the approach to the A487 there is a long steep gradient of 5% which is within a cutting of up to 22m in depth.
Extent of WS2+1 carriageway. This route is made up of three sections of WS2+1 standard carriageway connected by roundabouts as follows:
Section 1 chainage 0 – 3,450 (Pink Option)
Section 2 chainage 3,450 – 6,500 (A487 to A4086 adjacent to Cibyn Industrial Estate)
Section 3 chainage 6,500 – 10,900 (A4086 to A487 at Plas Menai roundabout)
The extent WS2+1 carriageway for the Pink Option is as previously described. The other sections are as follows;

Appraisal Criteria	Assessment	Distribution	Significance
Landscape and townscape	Proposals include elements contradictory to existing topography and result in the loss of field patterns, boundaries and woodland. Introduction of engineered element into rural landscape affects both townscape character and visual context.	Welsh Highland Railway/ Afon Seiont crossings and Menai scarp cutting in particular.	Moderate Adverse (--)
Bio-diversity	There is a crossing of the Afon Gwyrfai which is designated as a SAC and SSSI, this is the most important feature potentially impacted upon. In this location there are potential impacts upon Otter, fish species, habitats, bat feeding sites etc. At the location where the Afon Gwyrfai is crossed there is relatively limited riparian habitat however so the impact would be reduced, also it is understood that the road would pass over the river at height with no structures in the river therefore reducing impacts. Also of particular significance is the crossing of the Afon Seiont, this does not have statutory designation but it, and the surrounding habitats are designated as Wildlife Sites (non-statutory) and represent a good mosaic of valuable habitats as well as supporting many of the important protected species that are also present in the Afon Gwyrfai. Bats, Otters, Barn Owls, breeding birds, reptiles, fish and Brown Hare are all likely to be impacted upon. The impact is considered to be Moderate adverse and Slight/moderate adverse where the Afon Gwyrfai and Afon Seiont respectively are being crossed (this could be downgraded by careful mitigation and programming of works). There will be slight/moderate adverse impacts where the Felinwnda, Waenfawr Road and Afon Seiont Mosaic (North) Wildlife Sites are impacted and also where the option passes close to certain areas of marshy grassland or impacts upon areas of semi-improved grassland. The impact upon bats, otters and Brown Hare is considered to be moderate with slight/moderate impacts upon breeding birds, reptiles, fish and Badgers. The impacts are however generally slight adverse over much of the habitat to be impacted and other species.	The most significant potential impacts are focused upon the Afon Gwyrfai and Afon Seiont with valuable habitats and protected species concentrated within these areas. Potential impacts are generally much reduced over the majority of this option, although the impacts on a number of protected species and particularly the widespread distribution of bats (especially Lesser Horseshoe Bats) needs particular consideration.	Moderate Adverse (--)

Yellow Option Description – This is effectively the same as the Purple Option except for the section of the route beyond chainage 8,000m. Instead of tying into the A487 at the Felinheli Bypass the route deviates north and links into the A487 at the Plas Menai roundabout. This results in a shorter route by up to 1km. On this section there is a high embankment of up to 9m as the route crosses the B4366 and on the approach to the A487 there is a long steep gradient of 5% which is within a cutting of up to 22m in depth.
Extent of WS2+1 carriageway. This route is made up of three sections of WS2+1 standard carriageway connected by roundabouts as follows:
Section 1 chainage 0 – 3,450 (Pink Option)
Section 2 chainage 3,450 – 6,500 (A487 to A4086 adjacent to Cibyn Industrial Estate)
Section 3 chainage 6,500 – 10,900 (A4086 to A487 at Plas Menai roundabout)
The extent WS2+1 carriageway for the Pink Option is as previously described. The other sections are as follows;

Appraisal Criteria	Assessment	Distribution	Significance
Heritage	No physical impact on SAMs. One Grade II Listed milestone requiring relocation. Two non-statutory archaeological sites subject to physical impact during road construction (buried section of Roman road, and Post-Medieval trackway). Very Large impact on the historic setting of Caerlan Tibot SAM; Moderate adverse impact on the historic setting of two other SAMs and five Grade II Listed Buildings Potential impact upon new (i.e. undiscovered) archaeological sites is unknown. However, the archaeological potential of the northernmost part of this route is high	Caernarfon / Bontnewydd Area	Moderate/Large Adverse (--/---)
Water environment	In general, the construction of new roadways through a 'greenfield' will increase surface water runoff, obstruct flood flow within the floodplain and cause a loss of flood plain storage if no mitigation measures are established. The crossing of the Afon Gwyrfai floodplain (via viaduct) will obstruct flood flow and cause a loss of flood storage and cannot be fully mitigated. Culverting 'main rivers' may also obstruct flood flow. General mitigation works include the attenuation of surface water runoff before discharging into watercourses, installing pollution control measures in high risk areas, crossing of watercourses to span the entire floodplain, and increasing culvert sizes at road crossings. The significance of effect has been determined for the design year and post-mitigation.	Afons Gwyrfai, Seiont, Cadnant and Rhyd.	Moderate Adverse (--)
Soils	The possible impact on the mineral resources at Caernarfon Quarry	Caernarfon Seiont Quarry	Moderate Adverse (--)
Society			
Transport safety	Number of accidents saved: 3,574 – 2,588 = 986 PVB = £172.2M - £129.0M = £43.2M The 2+1 carriageway standard provides safe overtaking opportunities.	All road users	Large Beneficial (+++)
Personal security		General population throughout Bontnewydd, Dinas Caernarfon and surrounding settlements.	Neutral (0)

Yellow Option Description – This is effectively the same as the Purple Option except for the section of the route beyond chainage 8,000m. Instead of tying into the A487 at the Felinheli Bypass the route deviates north and links into the A487 at the Plas Menai roundabout. This results in a shorter route by up to 1km. On this section there is a high embankment of up to 9m as the route crosses the B4366 and on the approach to the A487 there is a long steep gradient of 5% which is within a cutting of up to 22m in depth.
Extent of WS2+1 carriageway. This route is made up of three sections of WS2+1 standard carriageway connected by roundabouts as follows:
Section 1 chainage 0 – 3,450 (Pink Option)
Section 2 chainage 3,450 – 6,500 (A487 to A4086 adjacent to Cibyn Industrial Estate)
Section 3 chainage 6,500 – 10,900 (A4086 to A487 at Plas Menai roundabout)
The extent WS2+1 carriageway for the Pink Option is as previously described. The other sections are as follows;

Appraisal Criteria	Assessment	Distribution	Significance
Permeability	The bypass will substantially reduce community severance within the settlements of Bontnewydd and Dinas (+++) by reducing predicted traffic flows (AADT). It would reduce severance to a lesser extent through Caernarfon (++). However, this relief from existing severance would be limited to the communities of Bontnewydd, Dinas and Caernarfon as other settlements, such as Caeathro, Waunfawr, Llanrug or Bethal would not experience any significant relief from severance (0). Major Beneficial overall (+++).	Relief from severance limited to communities of Bontnewydd, Dinas and Caernarfon.	Large Beneficial (+++)
Physical Fitness	The bypass does nothing directly to encourage active modes of transport within Bontnewydd, Dinas, Caernarfon or other nearby settlements. As it will reduce congestion through Bontnewydd and Dinas it may encourage more car use, however it may also encourage more travel by active modes such as walking and cycling (0). A total of 5 public rights of way will be severed by the proposal. Despite diversions being put in place, losses in amenity value of these routes may dissuade people from using them (-). Slight adverse overall (-).	General population throughout Bontnewydd, Dinas and Caernarfon and users of public rights of way.	Slight Adverse (-)
Social Inclusion	Full bypass option of all communities further benefits journey times to populations west and south and increases accessibility contours. Moderate Beneficial overall (++).	Populations to the west and south	Moderate Beneficial (++)
Equality, Diversity & Human Rights	The Option is unlikely to have any impacts in relation to the race, ethnicity, colour or nationality, sex or marital status, disability: (physical, sensory or mental), age, religion or belief and sexual orientation (0). The provision of a new bypass does have the potential to encourage travel from non-Welsh speaking areas into this predominantly Welsh speaking area. This might lead to a dilution of the strong Welsh language culture within the area (-). Minor adverse overall (-).	Potential impacts on strong Welsh language culture of the area.	Slight Adverse (-)
Transport Planning Objectives			
TPO 1	Large Beneficial (+++) By 2016 journey time reduced by an average of 7 minutes throughout the day between Llanwnda and Plas Menai.		
TPO 2	Moderate Beneficial (++) By 2016 journey time reduced by an average of 4 minutes throughout the day between Llanwnda and Caernarfon.		

Yellow Option Description – This is effectively the same as the Purple Option except for the section of the route beyond chainage 8,000m. Instead of tying into the A487 at the Felinheli Bypass the route deviates north and links into the A487 at the Plas Menai roundabout. This results in a shorter route by up to 1km. On this section there is a high embankment of up to 9m as the route crosses the B4366 and on the approach to the A487 there is a long steep gradient of 5% which is within a cutting of up to 22m in depth.
Extent of WS2+1 carriageway. This route is made up of three sections of WS2+1 standard carriageway connected by roundabouts as follows:
Section 1 chainage 0 – 3,450 (Pink Option)
Section 2 chainage 3,450 – 6,500 (A487 to A4086 adjacent to Cibyn Industrial Estate)
Section 3 chainage 6,500 – 10,900 (A4086 to A487 at Plas Menai roundabout)
The extent WS2+1 carriageway for the Pink Option is as previously described. The other sections are as follows;

Appraisal Criteria	Assessment	Distribution	Significance
TPO 3	Moderate Beneficial (++) By 2016 the number of vehicles through Dinas along the A487 reduces by 79% based on 24hr AADT flow. By 2016 the number of vehicles through Caernarfon along the A487 reduces by 24% based on 24hr AADT flow.		
TPO 4	Large Beneficial (+++) By 2016 accidents reduce by 57% along the A487. This meets the 22% reduction outlined in the TPOs.		
TPO 5	Large Beneficial (+++) Improved network resilience; by-pass provides a secondary route from north to south.		
Public acceptability:	Acceptable. Benefits wider communities. Less of a strategic link. Locally provides connections to North Caernarfon and Cibyn. CPO required across entire route but specifically across Caernarfon Quarry and Glan Gwna Caravan Park.		
Acceptability to other stakeholders:	Acceptable to wider councillors, within the study area. Consultation with EA held over the River Seiont / Glan Gwna structure to consider flood capacity. Consultation undertaken with CCW to minimise environmental risks. Acceptable to Gwynedd Council. Consultation with EA on flooding of Gwyrfai – structure modified to suit. CCW consulted on SAC and SSSI issues. Western route acceptable.		
Technical and operational feasibility:	Presently three relaxations in SSD but likely that these can be designed out at greater level of detail. Therefore anticipated that it could be built to full 2+1 standard. Flood relief structure – significant structure for size of scheme. Welsh Highland Railway – likely some closure / possession required. Large structure at Glan Gwna.		
Financial affordability and deliverability:	£7.9M/km Consultation held with DVO regarding larger areas of compensation at the Caravan Park and the Quarry. Could be built in phases.		

Yellow Option Description – This is effectively the same as the Purple Option except for the section of the route beyond chainage 8,000m. Instead of tying into the A487 at the Felinheli Bypass the route deviates north and links into the A487 at the Plas Menai roundabout. This results in a shorter route by up to 1km. On this section there is a high embankment of up to 9m as the route crosses the B4366 and on the approach to the A487 there is a long steep gradient of 5% which is within a cutting of up to 22m in depth.
Extent of WS2+1 carriageway. This route is made up of three sections of WS2+1 standard carriageway connected by roundabouts as follows:
Section 1 chainage 0 – 3,450 (Pink Option)
Section 2 chainage 3,450 – 6,500 (A487 to A4086 adjacent to Cibyn Industrial Estate)
Section 3 chainage 6,500 – 10,900 (A4086 to A487 at Plas Menai roundabout)
The extent WS2+1 carriageway for the Pink Option is as previously described. The other sections are as follows;

Appraisal Criteria	**Assessment**	**Distribution**	**Significance**
Risks:	Design and CPO across the quarry. Funding risks are known and are manageable. Flood modelling required at future stages.		
Comment:			

Black Option

Black Option Description – The Black Option was suggested as a variation to the Purple following the initial Public Consultation. Similarly, the Orange Option has resulted as a variation to the Yellow Option. In reporting the changes to the vertical and horizontal alignment, this section covers only those parts of the Black option which differs to the Purple and Yellow Options. All other sections remain unchanged and the reporting of these is covered under the Purple and Yellow (and Pink) Option descriptions. The Black Option is the section which is new, not previously described in the report and common to both the Black and Orange Options is between the proposed Bontnewydd (Meifod) roundabout on the A487 and the proposed Cibyn Industrial Estate roundabout. The alternative removes the section from the Purple and Yellow Options adjacent to Caernarfon Quarry, and introduces a variation which uses part of the unofficial bypass into the existing Caeathro roundabout and then, offline, crosses the River Seiont into the proposed Cibyn roundabout. For completeness, brief descriptions are given for the directionality of the WS 2+1 etc for both options separately and in full (i.e. chainage 0 to the end). The Black Option is in total a length of 11.8km (which is approximately 800m longer than the Purple). This route is made up of four sections of WS2+1 standard carriageway, connected by proposed roundabouts as follows:

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 11,800 Bypass of Pont Rug and Crug connecting to the existing Felinheli bypass.

Appraisal Criteria	Assessment	Distribution	Significance
Economy			
Transport Economic Efficiency	Scheme Costs: £80.9M PVC: £91.5M PVB: £410.2M NPV: £318.7M BCR: 4.48	All road users to benefit from reduced journey times and vehicle operating costs The local economy will benefit although disbenefit to businesses on old route.	Large Beneficial (+++) Moderate Beneficial (++)
EALI (wider economic Impacts)	This option has the potential to open up development possibilities at junction locations. The bypass may also act as a boundary to which development may encroach. Disbenefit to north of Caernarfon as no connection to Plas Menai.		
Environment			
Noise	The Black Option results in traffic being diverted off the current A487 along which many Noise Sensitive Receptors (NSR) currently occupy roadside positions. This results in significant traffic reductions along the current route. A significant number of NSRs will therefore experience traffic noise reductions. A number of NSRs that currently experience very little traffic noise will experience small increases in traffic noise along the new route along the new route by-passing Bontnewydd, depending on their proximity to the new road, and their distance from current roads.	Bontnewydd & Caernarfon	Moderate Beneficial (++)
Local Air Quality	192 properties will experience an increase in PM_{10} and NO_2 respectively.	Benefits weighted towards the residents of Bontnewydd and	Slight Beneficial

Black Option Description – The Black Option was suggested as a variation to the Purple following the initial Public Consultation. Similarly, the Orange Option has resulted as a variation to the Yellow Option. In reporting the changes to the vertical and horizontal alignment, this section covers only those parts of the Black option which differs to the Purple and Yellow Options. All other sections remain unchanged and the reporting of these is covered under the Purple and Yellow (and Pink) Option descriptions. The Black Option is the section which is new, not previously described in the report and common to both the Black and Orange Options is between the proposed Bontnewydd (Meifod) roundabout on the A487 and the proposed Cibyn Industrial Estate roundabout. The alternative removes the section from the Purple and Yellow Options adjacent to Caernarfon Quarry, and introduces a variation which uses part of the unofficial bypass into the existing Caeathro roundabout and then, offline, crosses the River Seiont into the proposed Cibyn roundabout. For completeness, brief descriptions are given for the directionality of the WS 2+1 etc for both options separately and in full (i.e. chainage 0 to the end). The Black Option is in total a length of 11.8km (which is approximately 800m longer than the Purple). This route is made up of four sections of WS2+1 standard carriageway, connected by proposed roundabouts as follows:

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 11,800 Bypass of Pont Rug and Crug connecting to the existing Felinheli bypass.

Appraisal Criteria	**Assessment**	**Distribution**	**Significance**
	2730 properties will experience a reduction in PM_{10} and NO_2 respectively.	Caernarfon.	(+)
Greenhouse Gas Emissions	CO_2 emissions – decrease of 590 tonnes in opening year. NPV of cost £1,951,000		Moderate Beneficial (++)
Landscape and townscape	Proposals include elements contradictory to existing topography and result in the loss of field patterns, boundaries and woodland. Embankment forms in particular introduce engineered elements into the rural landscape, whilst localised loss of woodland alters landscape character.	Welsh Highland Railway and Afon Seiont crossings in particular	Moderate Adverse (--)
Bio-diversity	There is a crossing of the Afon Gwyrfai which is designated as a SAC and SSSI, this is the most important feature potentially impacted upon. In this location there are potential impacts upon Otter, fish species, habitats, bat feeding sites etc. At the location where the Afon Gwyrfai is crossed there is relatively limited riparian habitat however so the impact would be reduced, also it is understood that the road would pass over the river at height with no structures in the river therefore reducing impacts. Also of particular significance is the crossing of the Afon Seiont, this does not have statutory designation but it, and the surrounding habitats are designated as Wildlife Sites (non-statutory) and represent a good mosaic of valuable habitats as well as supporting many of the important protected species that are also present in the Afon Gwyrfai. The location where this option crosses the Afon Seiont has a potentially greater impact than the Purple and Yellow Options due to the more semi-natural form of the river and more extensive areas of woodland flanking the river at this location. Bats, Otters, Barn Owls, breeding birds, reptiles, amphibians, fish and Brown Hare are all likely to be impacted upon.	The most significant potential impacts are focused upon the Afon Gwyrfai and Afon Seiont with valuable habitats and protected species concentrated in these areas. Significant impacts upon a number of Wildlife Sites collectively increase the overall impact. Potential impacts are generally much reduced over the majority of this option, although the impacts on Wildlife Sites and protected species and particularly the widespread distribution of bats (especially Lesser Horseshoe Bats) needs	Moderate/Large Adverse (--/---)

Black Option Description – The Black Option was suggested as a variation to the Purple following the initial Public Consultation. Similarly, the Orange Option has resulted as a variation to the Yellow Option. In reporting the changes to the vertical and horizontal alignment, this section covers only those parts of the Black option which differs to the Purple and Yellow Options. All other sections remain unchanged and the reporting of these is covered under the Purple and Yellow (and Pink) Option descriptions. The Black Option is the section which is new, not previously described in the report and common to both the Black and Orange Options is between the proposed Bontnewydd (Meifod) roundabout on the A487 and the proposed Cibyn Industrial Estate roundabout. The alternative removes the section from the Purple and Yellow Options adjacent to Caernarfon Quarry, and introduces a variation which uses part of the unofficial bypass into the existing Caeathro roundabout and then, offline, crosses the River Seiont into the proposed Cibyn roundabout. For completeness, brief descriptions are given for the directionality of the WS 2+1 etc for both options separately and in full (i.e. chainage 0 to the end). The Black Option is in total a length of 11.8km (which is approximately 800m longer than the Purple). This route is made up of four sections of WS2+1 standard carriageway, connected by proposed roundabouts as follows:

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 11,800 Bypass of Pont Rug and Crug connecting to the existing Felinheli bypass.

Appraisal Criteria	Assessment	Distribution	Significance
	The impact is considered to be Moderate adverse where both the Afon Gwyrfai and Afon Seiont are being crossed (this could be downgraded by careful mitigation and programming of works). Viewed in isolation there will be slight/moderate adverse impacts where a variety of Wildlife Sites are crossed, namely the Cae-rhydau, Afon Seiont Mosaic (South), Afon Seiont Mosaic (East), Maes Merddin and Afon Beuno Wildlife Sites. Collectively however the impact on the variety of habitats particularly those within designated sites increases the impact to moderate/large negative. The impact upon otters, breeding birds and bats is considered to be moderate and the impact is considered to be slight/moderate upon fish, Brown Hare and Badgers. The impacts are however generally slight adverse over much of the habitat to be impacted and other species. It is particularly recognised that parts of this option are on-line thus reducing impacts in comparison with the Purple and Yellow Options.	particular consideration. The on-line sections reduce the impacts (although many are at close proximity to Wildlife Sites).	
Heritage	No physical impact on SAMs. Two non-statutory archaeological sites subject to physical impact during road construction (buried section of Roman road, and Post-Medieval trackway). Moderate adverse impact on the historic setting of three SAMs. Major adverse impact upon the historic setting of one Grade II* and three Grade II Listed Buildings. Moderate adverse impact upon the historic setting of one Grade II* and seven Grade II Listed Buildings Potential impact upon new (i.e. undiscovered) archaeological sites is unknown.	N/A	Moderate Adverse (--)

Black Option Description – The Black Option was suggested as a variation to the Purple following the initial Public Consultation. Similarly, the Orange Option has resulted as a variation to the Yellow Option. In reporting the changes to the vertical and horizontal alignment, this section covers only those parts of the Black option which differs to the Purple and Yellow Options. All other sections remain unchanged and the reporting of these is covered under the Purple and Yellow (and Pink) Option descriptions. The Black Option is the section which is new, not previously described in the report and common to both the Black and Orange Options is between the proposed Bontnewydd (Meifod) roundabout on the A487 and the proposed Cibyn Industrial Estate roundabout. The alternative removes the section from the Purple and Yellow Options adjacent to Caernarfon Quarry, and introduces a variation which uses part of the unofficial bypass into the existing Caeathro roundabout and then, offline, crosses the River Seiont into the proposed Cibyn roundabout. For completeness, brief descriptions are given for the directionality of the WS 2+1 etc for both options separately and in full (i.e. chainage 0 to the end). The Black Option is in total a length of 11.8km (which is approximately 800m longer than the Purple). This route is made up of four sections of WS2+1 standard carriageway, connected by proposed roundabouts as follows:

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 11,800 Bypass of Pont Rug and Crug connecting to the existing Felinheli bypass.

Appraisal Criteria	**Assessment**	**Distribution**	**Significance**
Water environment	In general, the construction of new roadways through a 'greenfield' will increase surface water runoff, obstruct flood flow within the floodplain and cause a loss of flood plain storage if no mitigation measures are established. The crossing of the Afon Gwyrfai floodplain (via viaduct) will obstruct flood flow and cause a loss of flood storage and cannot be fully mitigated. Culverting 'main rivers' may also obstruct flood flow. General mitigation works include the attenuation of surface water runoff before discharging into watercourses, installing pollution control measures in high risk areas, crossing of watercourses to span the entire floodplain, and increasing culvert sizes at road crossings. The significance of effect has been determined for the design year and post-mitigation.	Afon Gwyrfai, Seiont, Cadnant and Rhyd.	Moderate Adverse (--)
Soils	The possible impact from the construction of embankments along the route. The possible impact of contamination to the east of Cibyn Industrial Estate.	Entire area for embankment / Cibyn Industrial Estate	Moderate Adverse (--)
Society			
Transport safety	Number of accidents saved: 3,574 – 2,612 = 962 PVB = £172.2M - £131.3M = £40.9M The 2+1 carriageway standard provides safe overtaking opportunities.	All road users	Large Beneficial (+++)
Personal security		General population throughout Bontnewydd, Dinas Caernarfon and surrounding settlements.	Neutral (0)

Black Option Description – The Black Option was suggested as a variation to the Purple following the initial Public Consultation. Similarly, the Orange Option has resulted as a variation to the Yellow Option. In reporting the changes to the vertical and horizontal alignment, this section covers only those parts of the Black option which differs to the Purple and Yellow Options. All other sections remain unchanged and the reporting of these is covered under the Purple and Yellow (and Pink) Option descriptions. The Black Option is the section which is new, not previously described in the report and common to both the Black and Orange Options is between the proposed Bontnewydd (Meifod) roundabout on the A487 and the proposed Cibyn Industrial Estate roundabout. The alternative removes the section from the Purple and Yellow Options adjacent to Caernarfon Quarry, and introduces a variation which uses part of the unofficial bypass into the existing Caeathro roundabout and then, offline, crosses the River Seiont into the proposed Cibyn roundabout. For completeness, brief descriptions are given for the directionality of the WS 2+1 etc for both options separately and in full (i.e. chainage 0 to the end). The Black Option is in total a length of 11.8km (which is approximately 800m longer than the Purple). This route is made up of four sections of WS2+1 standard carriageway, connected by proposed roundabouts as follows:

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 11,800 Bypass of Pont Rug and Crug connecting to the existing Felinheli bypass.

Appraisal Criteria	Assessment	Distribution	Significance
Permeability	The bypass will substantially reduce community severance within the settlements of Bontnewydd and Dinas (+++) by reducing predicted traffic flows (AADT). It would also reduce severance to a lesser extent through Caernarfon (++). However, this relief from existing severance would be limited to the communities of Bontnewydd, Dinas and Caernarfon as other settlements, such as, Waunfawr, Llanrug or Bethel would not experience any significant relief from severance (0). Slight decrease of traffic flow through the community of Caeathro. Moderate Beneficial overall (++).	Relief from severance limited to communities of Bontnewydd, Dinas and Caernarfon.	Moderate Beneficial (++)
Physical Fitness	Without direct provision for cyclist and pedestrians, the bypass does nothing directly to encourage active modes of transport within Bontnewydd, Dinas or Caernarfon (0). However the reduction of congestion through Bontnewydd and Dinas may encourage more travel by active modes such as walking and cycling. However the increase in traffic flow along the Bontnewydd – Pont Rug route may discourage more travel by active modes such as walking and cycling (--). A total of 11 public rights of way will be severed by the proposal. Despite diversions being put in place, losses in amenity value of these routes may dissuade people from using them (-). Moderate adverse overall (--).	General population throughout Bontnewydd, Dinas and Caernarfon and users of public rights of way.	Moderate Adverse (--)
Social Inclusion	Although a full bypass solution will have beneficial effects in terms of social inclusion, increases in junction number onto the main road is unlikely to markedly increase accessibility contours and improve accessibly based upon criteria (+). Slight beneficial overall (+)	Populations west and south	Slight Beneficial (+)
Equality, Diversity &	The Option is unlikely to have any impacts in relation to the race, ethnicity, colour or nationality, sex or marital status, disability: (physical, sensory or	Potential impacts on strong Welsh language culture of the	Slight Adverse

Black Option Description – The Black Option was suggested as a variation to the Purple following the initial Public Consultation. Similarly, the Orange Option has resulted as a variation to the Yellow Option. In reporting the changes to the vertical and horizontal alignment, this section covers only those parts of the Black option which differs to the Purple and Yellow Options. All other sections remain unchanged and the reporting of these is covered under the Purple and Yellow (and Pink) Option descriptions. The Black Option is the section which is new, not previously described in the report and common to both the Black and Orange Options is between the proposed Bontnewydd (Meifod) roundabout on the A487 and the proposed Cibyn Industrial Estate roundabout. The alternative removes the section from the Purple and Yellow Options adjacent to Caernarfon Quarry, and introduces a variation which uses part of the unofficial bypass into the existing Caeathro roundabout and then, offline, crosses the River Seiont into the proposed Cibyn roundabout. For completeness, brief descriptions are given for the directionality of the WS 2+1 etc for both options separately and in full (i.e. chainage 0 to the end). The Black Option is in total a length of 11.8km (which is approximately 800m longer than the Purple). This route is made up of four sections of WS2+1 standard carriageway, connected by proposed roundabouts as follows:

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 11,800 Bypass of Pont Rug and Crug connecting to the existing Felinheli bypass.

Appraisal Criteria	Assessment	Distribution	Significance
Human Rights	mental), age, religion or belief and sexual orientation (0). The provision of a new bypass does have the potential to encourage travel from non-Welsh speaking areas into this predominantly Welsh speaking area. This might lead to a dilution of the strong Welsh language culture within the area (-). Slight Adverse overall (-).	area.	(-)
Transport Planning Objectives			
TPO 1	**Moderate Beneficial (++)** By 2016 journey time reduced by an average of 3 minutes throughout the day between Llanwnda and Plas Menai.		
TPO 2	**Moderate Beneficial (++)** By 2016 journey time reduced by an average of 4 minutes throughout the day between Llanwnda and Caernarfon.		
TPO 3	**Large Beneficial (+++)** By 2016 the number of vehicles through Dinas along the A487 reduces by 82% based on 24hr AADT flow. By 2016 the number of vehicles through Caernarfon along the A487 reduces by 28% based on 24hr AADT flow.		
TPO 4	**Large Beneficial (+++)** By 2016 accidents reduce by 59% along the A487. This meets the 22% reduction outlined in the TPOs.		
TPO 5	**Moderate Beneficial (++)** Improved network resilience; by-pass provides a secondary route from north to south.		
Public acceptability:	Acceptable. Has wider benefits for communities of Bontnewydd, Dinas, Caernarfon, Caeathro and Bethel. A strategic link which would benefit wider		

Black Option Description – The Black Option was suggested as a variation to the Purple following the initial Public Consultation. Similarly, the Orange Option has resulted as a variation to the Yellow Option. In reporting the changes to the vertical and horizontal alignment, this section covers only those parts of the Black option which differs to the Purple and Yellow Options. All other sections remain unchanged and the reporting of these is covered under the Purple and Yellow (and Pink) Option descriptions. The Black Option is the section which is new, not previously described in the report and common to both the Black and Orange Options is between the proposed Bontnewydd (Meifod) roundabout on the A487 and the proposed Cibyn Industrial Estate roundabout. The alternative removes the section from the Purple and Yellow Options adjacent to Caernarfon Quarry, and introduces a variation which uses part of the unofficial bypass into the existing Caeathro roundabout and then, offline, crosses the River Seiont into the proposed Cibyn roundabout. For completeness, brief descriptions are given for the directionality of the WS 2+1 etc for both options separately and in full (i.e. chainage 0 to the end). The Black Option is in total a length of 11.8km (which is approximately 800m longer than the Purple). This route is made up of four sections of WS2+1 standard carriageway, connected by proposed roundabouts as follows:

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 11,800 Bypass of Pont Rug and Crug connecting to the existing Felinheli bypass.

Appraisal Criteria	Assessment	Distribution	Significance
	public to a greater extent. Makes use of existing road corridor and provides further local connections with a link to the Cibyn Industrial Estate. Will adversely affect residents along existing "unofficial bypass". Significant impact upon Girl Guides property. Proximity to Kent Farm and Seiont nurseries and campsite. 47 properties are affected. Reduces impact on Glan Gwna. Maintains traffic flow via Caeathro roundabout.		
Acceptability to other stakeholders:	Consultation undertaken with CCW to minimise environmental risks. Consultation with EA on flooding of Gwyrfai – structure modified to suit. CCW consulted on SAC and SSSI issues and confirmed western route of Bontnewydd acceptable. Consultation with Gwynedd Council required.		
Technical and operational feasibility:	Flood relief structure over River Gwyrfai – significant structure for size of scheme. Welsh Highland Railway – likely some closure / possession required. Large structure over River Seiont in deep river valley. Caeathro Pont Rug road closed between Bontnewydd and Caeathro for 12 months during construction. Link removed in the permanent works. Single relaxation to the horizontal alignment between Ch 6,762 – 6,910. Also, similar departures required at the Felinheli junction as per the Purple Option.		
Financial affordability and deliverability:	£6.9M/km. Could be built in phases. Cost comparable to the Yellow Option.		
Risks:	Funding risks are known and are manageable. Level of detailed design yet to be undertaken at Felinheli Junction. Consultation with GCC required. Flood modelling required at future stages.		

Black Option Description – The Black Option was suggested as a variation to the Purple following the initial Public Consultation. Similarly, the Orange Option has resulted as a variation to the Yellow Option. In reporting the changes to the vertical and horizontal alignment, this section covers only those parts of the Black option which differs to the Purple and Yellow Options. All other sections remain unchanged and the reporting of these is covered under the Purple and Yellow (and Pink) Option descriptions. The Black Option is the section which is new, not previously described in the report and common to both the Black and Orange Options is between the proposed Bontnewydd (Meifod) roundabout on the A487 and the proposed Cibyn Industrial Estate roundabout. The alternative removes the section from the Purple and Yellow Options adjacent to Caernarfon Quarry, and introduces a variation which uses part of the unofficial bypass into the existing Caeathro roundabout and then, offline, crosses the River Seiont into the proposed Cibyn roundabout. For completeness, brief descriptions are given for the directionality of the WS 2+1 etc for both options separately and in full (i.e. chainage 0 to the end). The Black Option is in total a length of 11.8km (which is approximately 800m longer than the Purple). This route is made up of four sections of WS2+1 standard carriageway, connected by proposed roundabouts as follows:

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 11,800 Bypass of Pont Rug and Crug connecting to the existing Felinheli bypass.

Appraisal Criteria	**Assessment**	**Distribution**	**Significance**
Comment:			

Orange Option

Orange Option Descriptions – Approx 10,460m in length. This route is made up of four sections of WS2+1 standard carriageway, connected by proposed roundabouts as follows:

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 10,460 Bypass of Crug and Pont Rug from Cibyn to the existing Plas Menai roundabout.

Appraisal Criteria	Assessment	Distribution	Significance
Economy			
Transport Economic Efficiency	Scheme Costs: £72.1M PVC: £81.4M PVB: £401.5M NPV: £320.0M BCR: 4.93	All road users to benefit from reduced journey times and vehicle operating costs	Large Beneficial (+++)
EALI (wider economic Impacts)	This option has the potential to open up development possibilities at junction locations, including the Cibyn Industrial Estate. The bypass may also act as a boundary to which development may encroach.	The local economy will benefit although disbenefit to businesses on old route.	Moderate Beneficial (++)
Environment			
Noise	The Orange Option results in traffic being diverted off the current A487 through Bontnewydd and Caernarfon along which many NSRs currently occupy roadside positions. This results in significant traffic reductions along the current A487 route. This is turn results in significant numbers of NSRs experiencing reductions in the associated traffic noise. Where the Orange options new route is through predominantly rural areas, a number of NSRs that currently experience very little traffic noise will experience increases in road traffic noise along the new route. Overall, approximately 4000 NSRs will experience decreases in road traffic noise with approximately 2000 NSRs experiencing increases in road traffic noise as a result of the scheme.	Bontnewydd, Caernarfon and the rural locations nearby the route of the 'unofficial A487 bypass'.	Moderate Beneficial (++)
Local Air Quality	192 properties experience an increase in PM_{10} and NO_2 respectively 2730 properties experience an decrease in PM_{10} and NO_2 respectively	Benefits weighted towards the residents of Bontnewydd and Caernarfon.	Slight Beneficial (+)
Greenhouse Gas Emissions	CO_2 emissions – decrease of 518 tonnes in opening year. NPV of cost £1,741,000		Moderate Beneficial (++)

Orange Option Descriptions – Approx 10,460m in length. This route is made up of four sections of WS2+1 standard carriageway, connected by proposed roundabouts as follows:

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 10,460 Bypass of Crug and Pont Rug from Cibyn to the existing Plas Menai roundabout.

Appraisal Criteria	Assessment	Distribution	Significance
Landscape and townscape	Proposals include elements contradictory to existing topography and result in the loss of field patterns, boundaries and woodland. Embankment forms in particular introduce engineered elements into the rural landscape, whilst localised loss of woodland alters landscape character. The cutting at the Plas Menai tie-in also has a significant landscape and visual impact..	Welsh Highland Railway and Afon Seiont crossings in particular	Moderate Adverse (--)
Bio-diversity	There is a crossing of the Afon Gwyrfai which is designated as a SAC and SSSI, this is the most important feature potentially impacted upon. In this location there are potential impacts upon Otter, fish species, habitats, bat feeding sites etc. At the location where the Afon Gwyrfai is crossed there is relatively limited riparian habitat however so the impact would be reduced, also it is understood that the road would pass over the river at height with no structures in the river therefore reducing impacts. Also of particular significance is the crossing of the Afon Seiont, this does not have statutory designation but it, and the surrounding habitats are designated as Wildlife Sites (non-statutory) and represent a good mosaic of valuable habitats as well as supporting many of the important protected species that are also present in the Afon Gwyrfai. The location where this option crosses the Afon Seiont has a potentially greater impact than the Purple and Yellow Options due to the more semi-natural form of the river and more extensive areas of woodland flanking the river at this location. Bats, Otters, Barn Owls, breeding birds, reptiles, amphibians, fish and Brown Hare are all likely to be impacted upon. The impact is considered to be Moderate adverse where both the Afon Gwyrfai and Afon Seiont are being crossed (this could be downgraded by careful mitigation and programming of works). Viewed in isolation there will be slight/moderate adverse impacts where a variety of Wildlife Sites are crossed, namely the Cae-rhydau, Afon Seiont Mosaic (South), Afon Seiont Mosaic (East), Maes Merddin and Afon Beuno Wildlife Sites. Collectively however the impact on the variety of habitats particularly those within designated sites increases the impact to moderate/large negative. The impact upon otters and bats is considered to be moderate and the impact is	The most significant potential impacts are focused upon the Afon Gwyrfai and Afon Seiont with valuable habitats and protected species concentrated in these areas. Significant impacts upon a number of Wildlife Sites collectively increase the overall impact. Potential impacts are generally much reduced over the majority of this option, although the impacts on Wildlife Sites and protected species, and particularly the widespread distribution of bats (especially Lesser Horseshoe Bats) needs particular consideration. The on-line sections reduce the impacts (although many are at close proximity to Wildlife Sites).	Moderate/Large Adverse (--/---)

Orange Option Descriptions – Approx 10,460m in length. This route is made up of four sections of WS2+1 standard carriageway, connected by proposed roundabouts as follows: Section 1 Ch 0 – 3,450 Bypass of Bontnewydd Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate. Section 4 Ch 7,250 – 10,460 Bypass of Crug and Pont Rug from Cibyn to the existing Plas Menai roundabout.			
Appraisal Criteria	**Assessment**	**Distribution**	**Significance**
	considered to be slight/moderate upon fish, Breeding birds and Badgers. The impacts are however generally slight adverse over much of the habitat to be impacted and other species. It is particularly recognised that parts of this option are on-line thus reducing impacts in comparison with the Purple and Yellow Options.		
Heritage	No physical impact on SAMs. Two non-statutory archaeological sites subject to physical impact during road construction (buried section of Roman road, and Post-Medieval trackway). Major adverse impact upon the setting of one SAM and a Moderate adverse impact on the historic setting of two SAMs. Major adverse impact upon the historic setting of one Grade II* and three Grade II Listed Buildings. Moderate adverse impact upon the historic setting of one Grade II* and seven Grade II Listed Buildings. Potential impact upon new (i.e. undiscovered) archaeological sites is unknown, but is predicted as high in the northern part of the option corridor.	N/A	Large/ Moderate Adverse (---/--)
Water environment	In general, the construction of new roadways through a 'greenfield' will increase surface water runoff, obstruct flood flow within the floodplain and cause a loss of flood plain storage if no mitigation measures are established. The crossing of the Afon Gwyrfai floodplain (via viaduct) will obstruct flood flow and cause a loss of flood storage and cannot be fully mitigated. Culverting 'main rivers' may also obstruct flood flow. General mitigation works include the attenuation of surface water runoff before discharging into watercourses, installing pollution control measures in high risk areas, crossing of watercourses to span the entire floodplain, and increasing culvert sizes at road crossings. The significance of effect has been determined for the design year and post-mitigation.	Afons Gwyrfai, Seiont, Cadnant and Rhyd.	Moderate Adverse (--)
Soils	The possible impact from the construction of embankments along the route. The possible impact of contamination to the east of Cibyn Industrial Estate.	Cibyn Industrial Estate	Slight Adverse (-)
Society			
Transport	Number of accidents saved: 3,574 – 2,592 = 982	All road users	Large Beneficial

Orange Option Descriptions – Approx 10,460m in length. This route is made up of four sections of WS2+1 standard carriageway, connected by proposed roundabouts as follows:

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 10,460 Bypass of Crug and Pont Rug from Cibyn to the existing Plas Menai roundabout.

Appraisal Criteria	Assessment	Distribution	Significance
safety	PVB = £172.2M - £129.1M = £43.1M The 2+1 carriageway standard provides safe overtaking opportunities.		(+++)
Personal security		General population throughout Bontnewydd, Dinas Caernarfon and surrounding settlements.	Neutral (0)
Permeability	The bypass will substantially reduce community severance within the settlements of Bontnewydd and Dinas (+++) by reducing predicted traffic flows (AADT). It would also reduce severance to a lesser extent through Caernarfon (++). However, this relief from existing severance would be limited to the communities of Bontnewydd, Dinas and Caernarfon as other settlements, such as, Waunfawr, Llanrug or Bethel would not experience any significant relief from severance (0). Major beneficial overall.	Relief from severance limited to communities of Bontnewydd, Dinas and Caernarfon.	Large Beneficial (+++)
Physical Fitness	Without direct provision for cyclist and pedestrians, the bypass does nothing directly to encourage active modes of transport within Bontnewydd, Dinas or Caernarfon (0). However the reduction of congestion through Bontnewydd and Dinas may encourage more travel by active modes such as walking and cycling. The Orange Option will also affect seven public rights of way, NCN route 8 and another cycleway. Impacts on these will be most severe in the construction phase, however diversions will be provided as appropriate following construction. Despite diversions being put in place losses in amenity value of these routes may dissuade people from using them. Slight adverse overall (-)	General population throughout Bontnewydd, Dinas and Caernarfon and users of public rights of way.	Slight Adverse (-)
Social Inclusion	Although a full bypass solution will have beneficial effects in terms of social inclusion, increases in junction number onto the main road is unlikely to markedly increase accessibility contours and improve accessibly based upon criteria (+). Slight beneficial overall (+)	Populations west and south	Slight Beneficial (+)
Equality, Diversity & Human Rights	The Option is unlikely to have any impacts in relation to the race, ethnicity, colour or nationality, sex or marital status, disability: (physical, sensory or mental), age, religion or belief and sexual orientation (0). The provision of a new bypass does have the potential to encourage travel from non-Welsh	Potential impacts on strong Welsh language culture of the area.	Slight Adverse (-)

Orange Option Descriptions – Approx 10,460m in length. This route is made up of four sections of WS2+1 standard carriageway, connected by proposed roundabouts as follows: Section 1 Ch 0 – 3,450 Bypass of Bontnewydd Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate. Section 4 Ch 7,250 – 10,460 Bypass of Crug and Pont Rug from Cibyn to the existing Plas Menai roundabout.			
Appraisal Criteria	**Assessment**	**Distribution**	**Significance**
	speaking areas into this predominantly Welsh speaking area. This might lead to a dilution of the strong Welsh language culture within the area (-). Slight Adverse overall (-).		
Transport Planning Objectives			
TPO 1	Moderate Beneficial (++) By 2016 journey time reduced by an average of 4 minutes throughout the day between Llanwnda and Plas Menai.		
TPO 2	Moderate Beneficial (++) By 2016 journey time reduced by an average of 4 minutes throughout the day between Llanwnda and Caernarfon.		
TPO 3	Moderate Beneficial (++) By 2016 the number of vehicles through Dinas along the A487 reduces by 82% based on 24hr AADT flow. By 2016 the number of vehicles through Caernarfon along the A487 reduces by 23% based on 24hr AADT flow.		
TPO 4	Large Beneficial (+++) By 2016 accidents reduce by 54% along the A487. This meets the 22% reduction outlined in the TPOs.		
TPO 5	Large Beneficial (+++) Improved network resilience; by-pass provides a secondary route from north to south.		
Public acceptability:	Acceptable. Has wider benefits for communities of Bontnewydd, Dinas, Caernarfon, Caeathro and Bethel. A strategic link which would benefit wider public to a greater extent. Makes use of existing road corridor and provides further local connections with a link to the Cibyn Industrial Estate. Will adversely affect residents along existing “unofficial bypass”. Significant impact upon Girl Guides property. Proximity to Kent Farm and Seiont nurseries and campsite. Reduces impact on Glan Gwna. 39 properties affected. Maintains traffic flow via Caeathro roundabout.		
Acceptability to other stakeholders:	Consultation undertaken with CCW to minimise environmental risks. Consultation with EA on flooding of Gwyrfai – structure modified to suit. CCW consulted on SAC and SSSI issues and confirmed western route of Bontnewydd acceptable. Consultation with Gwynedd Council required.		

Orange Option Descriptions – Approx 10,460m in length. This route is made up of four sections of WS2+1 standard carriageway, connected by proposed roundabouts as follows:

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 10,460 Bypass of Crug and Pont Rug from Cibyn to the existing Plas Menai roundabout.

Appraisal Criteria	**Assessment**	**Distribution**	**Significance**
Technical and operational feasibility:	Two relaxations in SSD. Flood relief structure over River Gwyrfai – significant structure for size of scheme. Welsh Highland Railway – likely some closure / possession required. Large structure over River Seiont in deep river valley. Caeathro Pont Rug road closed between Bontnewydd and Caeathro for 12 months during construction. Link removed in the permanent works.		
Financial affordability and deliverability:	£6.9M/km. Could be built in phases.		
Risks:	Funding risks are known and are manageable. Consultation with GCC required.	Flood modelling required at future stages.	
Comment:			

Red Option

Red Option Description – The Red Option is offered as variations to the Black Option; the Red being an alternative to the Black and the. The section which is new, and previously not described in full, is between the proposed Meifod (Bontnewydd) roundabout on the A487 and the unofficial bypass, into the Caeathro roundabout. In all other respects, the Red and Black share common alignments as do the Cyan and Orange. For completeness, brief descriptions are given for the directionality of the WS 2+1 etc for both options separately and in full (i.e. chainage 0 to the end). The more detailed alignment reporting in this section describes only the section offered as a variation to the Black and Orange Options. The Red Option is a total of 11.8km in length, which is the same as the Black Option.

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout, avoiding Gypsy Wood.
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 11,800 Bypass of Pont Rug and Crug connecting to the existing Felinheli bypass.

Appraisal Criteria	Assessment	Distribution	Significance
Economy			
Transport Economic Efficiency	Scheme Costs: £82.8 PVC: £93.5 PVB: £397.5 NPV: £304.0 BCR: 4.25	All road users to benefit from reduced journey times and vehicle operating costs	Large Beneficial (+++)
EALI (wider economic Impacts)	This option has the potential to open up development possibilities at junction locations. The bypass may also act as a boundary to which development may encroach. Disbenefit to north of Caernarfon as no connection to Plas Menai.	The local economy will benefit although disbenefit to businesses on old route.	Moderate Beneficial (++)
Environment			
Noise	The Red Option results in traffic being diverted off the current A487 through Bontnewydd and Caernarfon along which many NSRs currently occupy roadside positions. The Red option follows the route of the current 'unofficial bypass' more closely than some of the other bypass options. This results in fewer noise benefits due to traffic passing within the proximity of noise sensitive receptors. There are still significant traffic reductions along the current A487 route. This in turn results in significant numbers of NSRs experiencing reductions in the associated traffic noise. Where new roads travel through predominantly rural areas, a number of NSRs that currently experience very little traffic noise will experience increases in road traffic noise along the new route. Overall, approximately 4000 NSRs will experience decreases in road traffic noise with approximately 2000 NSRs experiencing increases in road traffic noise as a result of the Red scheme.	Bontnewydd, Caernarfon and the rural locations nearby the route of the 'unofficial A487 bypass'.	Moderate Beneficial (++)
Local Air	185 properties will experience an increase in PM_{10} and NO_2 respectively.	Benefits weighted towards	Slight Beneficial

Red Option Description – The Red Option is offered as variations to the Black Option; the Red being an alternative to the Black and the. The section which is new, and previously not described in full, is between the proposed Meifod (Bontnewydd) roundabout on the A487 and the unofficial bypass, into the Caeathro roundabout. In all other respects, the Red and Black share common alignments as do the Cyan and Orange. For completeness, brief descriptions are given for the directionality of the WS 2+1 etc for both options separately and in full (i.e. chainage 0 to the end). The more detailed alignment reporting in this section describes only the section offered as a variation to the Black and Orange Options. The Red Option is a total of 11.8km in length, which is the same as the Black Option.

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout, avoiding Gypsy Wood.
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 11,800 Bypass of Pont Rug and Crug connecting to the existing Felinheli bypass.

Appraisal Criteria	Assessment	Distribution	Significance
Quality	2730 properties will experience a reduction in PM_{10} and NO_2 respectively.	the residents of Bontnewydd and Caernarfon.	(+)
Greenhouse Gas Emissions	CO_2 emissions – decrease of 595 tonnes in opening year. NPV of cost £1,962,000		Moderate Beneficial (++)
Landscape and townscape	Proposals include elements contradictory to existing topography and result in the loss of field patterns, boundaries and woodland. Embankment forms in particular introduce engineered elements into the rural landscape, whilst localised loss of woodland alters landscape character.	Welsh Highland Railway and Afon Seiont crossings in particular	Moderate Adverse (--)
Bio-diversity	There is a crossing of the Afon Gwyrfai which is designated as a SAC and SSSI, this is the most important feature potentially impacted upon. In this location there are potential impacts upon Otter, fish species, habitats, bat feeding sites etc. At the location where the Afon Gwyrfai is crossed there is relatively limited riparian habitat however so the impact would be reduced, also it is understood that the road would pass over the river at height with no structures in the river therefore reducing impacts. Also of particular significance is the crossing of the Afon Seiont, this does not have statutory designation but it, and the surrounding habitats are designated as Wildlife Sites (non-statutory) and represent a good mosaic of valuable habitats as well as supporting many of the important protected species that are also present in the Afon Gwyrfai. The location where this option crosses the Afon Seiont has a potentially greater impact than the Purple and Yellow Options due to the more semi-natural form of the river and more extensive areas of woodland flanking the river at this location. Bats, Otters, Barn Owls, breeding birds, reptiles, amphibians, fish and Brown Hare are all likely to be impacted upon. The impact is considered to be Moderate adverse where both the Afon Gwyrfai	The most significant potential impacts are focused upon the Afon Gwyrfai and Afon Seiont with valuable habitats and protected species concentrated in these areas. Significant impacts upon a number of Wildlife Sites collectively increase the overall impact. Potential impacts are generally much reduced over the majority of this option, although the impacts on Wildlife Sites and protected species and particularly the widespread distribution of bats (especially Lesser Horseshoe Bats) needs	Moderate/Large Adverse (--/---)

Red Option Description – The Red Option is offered as variations to the Black Option; the Red being an alternative to the Black and the. The section which is new, and previously not described in full, is between the proposed Meifod (Bontnewydd) roundabout on the A487 and the unofficial bypass, into the Caeathro roundabout. In all other respects, the Red and Black share common alignments as do the Cyan and Orange. For completeness, brief descriptions are given for the directionality of the WS 2+1 etc for both options separately and in full (i.e. chainage 0 to the end). The more detailed alignment reporting in this section describes only the section offered as a variation to the Black and Orange Options. The Red Option is a total of 11.8km in length, which is the same as the Black Option.

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout, avoiding Gypsy Wood.
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 11,800 Bypass of Pont Rug and Crug connecting to the existing Felinheli bypass.

Appraisal Criteria	Assessment	Distribution	Significance
	and Afon Seiont are being crossed (this could be downgraded by careful mitigation and programming of works). Viewed in isolation there will be slight/moderate adverse impacts where a variety of Wildlife Sites are crossed, namely the Cae-rhydau, Afon Seiont Mosaic (South), Afon Seiont Mosaic (East), Maes Merddin and Afon Beuno Wildlife Sites. Collectively however the impact on the variety of habitats particularly those within designated sites increases the impact to moderate/large negative. The impact upon otters, breeding birds and bats is considered to be moderate and the impact is considered to be slight/moderate upon fish, Brown Hare and Badgers. The impacts are however generally slight adverse over much of the habitat to be impacted and other species. It is particularly recognised that parts of this option are on-line thus reducing impacts in comparison with the Purple and Yellow Options.	particular consideration. The on-line sections reduce the impacts (although many are at close proximity to Wildlife Sites).	
Heritage	No physical impact on SAMs. Two non-statutory archaeological sites subject to physical impact during road construction (buried section of Roman road, and Post-Medieval trackway). Moderate adverse impact on the historic setting of three SAMs. Major adverse impact upon the historic setting of one Grade II* and three Grade II Listed Buildings. Moderate adverse impact upon the historic setting of one Grade II* and seven Grade II Listed Buildings Potential impact upon new (i.e. undiscovered) archaeological sites is unknown.	N/A	Moderate Adverse (--)
Water environment	In general, the construction of new roadways through a 'greenfield' will increase surface water runoff, obstruct flood flow within the floodplain and cause a loss of flood plain storage if no mitigation measures are established. The crossing of the Afon Gwyrfai floodplain (via viaduct) will obstruct flood flow and cause a loss of flood storage and cannot be fully mitigated. Culverting 'main rivers' may also obstruct flood flow. General mitigation works include the attenuation of surface water runoff before discharging into watercourses, installing pollution control measures in high risk areas, crossing of watercourses to span the entire	Afon Gwyrfai, Seiont, Cadnant and Rhyd.	Moderate Adverse (--)

Red Option Description – The Red Option is offered as variations to the Black Option; the Red being an alternative to the Black and the. The section which is new, and previously not described in full, is between the proposed Meifod (Bontnewydd) roundabout on the A487 and the unofficial bypass, into the Caeathro roundabout. In all other respects, the Red and Black share common alignments as do the Cyan and Orange. For completeness, brief descriptions are given for the directionality of the WS 2+1 etc for both options separately and in full (i.e. chainage 0 to the end). The more detailed alignment reporting in this section describes only the section offered as a variation to the Black and Orange Options. The Red Option is a total of 11.8km in length, which is the same as the Black Option.

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout, avoiding Gypsy Wood.
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 11,800 Bypass of Pont Rug and Crug connecting to the existing Felinheli bypass.

Appraisal Criteria	Assessment	Distribution	Significance
	floodplain, and increasing culvert sizes at road crossings. The significance of effect has been determined for the design year and post-mitigation.		
Soils	The possible impact from the construction of embankments along the route. The possible impact of contamination to the east of Cibyn Industrial Estate.	Entire area for embankment / Cibyn Industrial Estate	Moderate Adverse (--)
Society			
Transport safety	Number of accidents saved: 3574 – 2995 = 579 PVB = £172.2M - £146.2M = £26M The 2+1 carriageway standard provides safe overtaking opportunities.	All road users	Large Beneficial (+++)
Personal security		General population throughout Bontnewydd, Dinas Caernarfon and surrounding settlements.	Neutral (0)
Permeability	The bypass will substantially reduce community severance within the settlements of Bontnewydd and Dinas (+++) by reducing predicted traffic flows (AADT). It would also reduce severance to a lesser extent through Caernarfon (++). However, this relief from existing severance would be limited to the communities of Bontnewydd, Dinas and Caernarfon as other settlements, such as, Waunfawr, Llanrug or Bethel would not experience any significant relief from severance (0). Slight decrease of traffic flow through the community of Caeathro. Moderate Beneficial overall (++).	Relief from severance limited to communities of Bontnewydd, Dinas and Caernarfon.	Moderate Beneficial (++)
Physical Fitness	Without direct provision for cyclist and pedestrians, the bypass does nothing directly to encourage active modes of transport within Bontnewydd, Dinas or Caernarfon (0). However the reduction of congestion through Bontnewydd and Dinas may encourage more travel by active modes such as walking and cycling. However the increase in traffic flow along the Bontnewydd – Pont Rug route may	General population throughout Bontnewydd, Dinas and Caernarfon and users of public rights of way.	Moderate Adverse (--)

Red Option Description – The Red Option is offered as variations to the Black Option; the Red being an alternative to the Black and the. The section which is new, and previously not described in full, is between the proposed Meifod (Bontnewydd) roundabout on the A487 and the unofficial bypass, into the Caeathro roundabout. In all other respects, the Red and Black share common alignments as do the Cyan and Orange. For completeness, brief descriptions are given for the directionality of the WS 2+1 etc for both options separately and in full (i.e. chainage 0 to the end). The more detailed alignment reporting in this section describes only the section offered as a variation to the Black and Orange Options. The Red Option is a total of 11.8km in length, which is the same as the Black Option.

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout, avoiding Gypsy Wood.
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 11,800 Bypass of Pont Rug and Crug connecting to the existing Felinheli bypass.

Appraisal Criteria	Assessment	Distribution	Significance
	discourage more travel by active modes such as walking and cycling (--). A total of 11 public rights of way will be severed by the proposal. Despite diversions being put in place, losses in amenity value of these routes may dissuade people from using them (-). Moderate adverse overall (--).		
Social Inclusion	Although a full bypass solution will have beneficial effects in terms of social inclusion, increases in junction number onto the main road is unlikely to markedly increase accessibility contours and improve accessibly based upon criteria (+). Slight beneficial overall (+)	Populations west and south	Slight Beneficial (+)
Equality, Diversity & Human Rights	The Option is unlikely to have any impacts in relation to the race, ethnicity, colour or nationality, sex or marital status, disability: (physical, sensory or mental), age, religion or belief and sexual orientation (0). The provision of a new bypass does have the potential to encourage travel from non-Welsh speaking areas into this predominantly Welsh speaking area. This might lead to a dilution of the strong Welsh language culture within the area (-). Slight Adverse overall (-).	Potential impacts on strong Welsh language culture of the area.	Slight Adverse (-)
Transport Planning Objectives			
TPO 1	Moderate Beneficial (++) By 2016 journey time reduced by an average of 3 minutes throughout the day between Llanwnda and Plas Menai.		
TPO 2	Moderate Beneficial (++) By 2016 journey time reduced by an average of 4 minutes throughout the day between Llanwnda and Caernarfon.		
TPO 3	Large Beneficial (+++) By 2016 the number of vehicles through Dinas along the A487 reduces by 82% based on 24hr AADT flow. By 2016 the number of vehicles through Caernarfon along the A487 reduces by 26% based on 24hr AADT flow.		
TPO 4	Large Beneficial (+++) By 2016 accidents reduce by 59% along the A487. This meets the 22% reduction outlined in the TPOs.		

Red Option Description – The Red Option is offered as variations to the Black Option; the Red being an alternative to the Black and the. The section which is new, and previously not described in full, is between the proposed Meifod (Bontnewydd) roundabout on the A487 and the unofficial bypass, into the Caeathro roundabout. In all other respects, the Red and Black share common alignments as do the Cyan and Orange. For completeness, brief descriptions are given for the directionality of the WS 2+1 etc for both options separately and in full (i.e. chainage 0 to the end). The more detailed alignment reporting in this section describes only the section offered as a variation to the Black and Orange Options. The Red Option is a total of 11.8km in length, which is the same as the Black Option.

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout, avoiding Gypsy Wood.
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 11,800 Bypass of Pont Rug and Crug connecting to the existing Felinheli bypass.

Appraisal Criteria	Assessment	Distribution	Significance
TPO 5	Moderate Beneficial (++) Improved network resilience; by-pass provides a secondary route from north to south.		
Public acceptability:	Acceptable. Has wider benefits for communities of Bontnewydd, Dinas, Caernarfon, Caeathro and Bethel. A strategic link which would benefit wider public to a greater extent. Makes use of existing road corridor and provides further local connections with a link to the Cibyn Industrial Estate. Will adversely affect residents along existing “unofficial bypass”. Significant impact upon Girl Guides property. Proximity to Kent Farm and Seiont nurseries and campsite. Reduces impact on Glan Gwna. Maintains traffic flow via Caeathro roundabout. 46 properties affected. Significant impact upon Gypsy Wood.		
Acceptability to other stakeholders:	Consultation undertaken with CCW to minimise environmental risks. Consultation with EA on flooding of Gwyrfai – structure modified to suit. CCW consulted on SAC and SSSI issues and confirmed western route of Bontnewydd acceptable. Consultation with Gwynedd Council required.		
Technical and operational feasibility:	Single relaxation to the horizontal alignment between Ch 6,762 – 6,910. Also, similar departures required at the Felinheli junction as per the Purple Option. Flood relief structure over River Gwyrfai – significant structure for size of scheme. Welsh Highland Railway – likely some closure / possession required. Large structure over River Seiont in deep river valley. Caeathro Pont Rug road closed between Bontnewydd and Caeathro for 8 months during construction.		
Financial affordability and deliverability:	£7M/km. Could be built in phases.		
Risks:	Funding risks are known and are manageable. Further design required at the Felinheli junction. Consultation with GCC required. Flood modelling required at		

Red Option Description – The Red Option is offered as variations to the Black Option; the Red being an alternative to the Black and the. The section which is new, and previously not described in full, is between the proposed Meifod (Bontnewydd) roundabout on the A487 and the unofficial bypass, into the Caeathro roundabout. In all other respects, the Red and Black share common alignments as do the Cyan and Orange. For completeness, brief descriptions are given for the directionality of the WS 2+1 etc for both options separately and in full (i.e. chainage 0 to the end). The more detailed alignment reporting in this section describes only the section offered as a variation to the Black and Orange Options. The Red Option is a total of 11.8km in length, which is the same as the Black Option.

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout, avoiding Gypsy Wood.
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 11,800 Bypass of Pont Rug and Crug connecting to the existing Felinheli bypass.

Appraisal Criteria	Assessment	Distribution	Significance
	future stages.		
Comment:			

Cyan Option

Cyan Option Description – The Cyan Option is offered as a variation to the Orange Option; the Red being an alternative to the Black and the Cyan an alternative to the Orange. The section which is new, and previously not described in full, is between the proposed Meifod (Bontnewydd) roundabout on the A487 and the unofficial bypass, into the Caeathro roundabout. In all other respects, the Cyan and Orange options share common alignments. For completeness, brief descriptions are given for the directionality of the WS 2+1 etc for both options separately and in full (i.e. chainage 0 to the end). The more detailed alignment reporting in this section describes only the section offered as a variation to the Black and Orange Options. The Cyan Option is the same as the Orange Option, and is 10.5km long.

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout, avoiding Gypsy Wood
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 10,460 Bypass of Crug and Pont Rug from Cibyn to the existing Plas Menai roundabout.

Appraisal Criteria	Assessment	Distribution	Significance
Economy			
Transport Economic Efficiency	Scheme Costs: £74.0 PVC: £83.3 PVB: £393.0 NPV: £309.6 BCR: 4.71	All road users to benefit from reduced journey times and vehicle operating costs	Large Beneficial (+++)
EALI (wider economic Impacts)	This option has the potential to open up development possibilities at junction locations, including the Cibyn Industrial Estate. The bypass may also act as a boundary to which development may encroach.	The local economy will benefit although disbenefit to businesses on old route.	Moderate Beneficial (++)
Environment			
Noise	The Cyan Option, much the same as the Red Option results in traffic being diverted off the current A487 through Bontnewydd and Caernarfon along which many NSRs currently occupy roadside positions. This results in significant traffic reductions along the current A487 route. The Cyan option also follows much of the route of the current 'unofficial bypass' more closely than some of the other bypass options. This in turn results in significant numbers of NSRs experiencing reductions in the associated traffic noise. Where the there is a new road through a predominantly rural area, a number of NSRs that currently experience very little traffic noise will experience increases in road traffic noise along the new route. Overall, approximately 4000 NSRs will experience decreases in road traffic noise with	Bontnewydd, Caernarfon and the rural locations nearby the route of the 'unofficial A487 bypass'.	Moderate Beneficial (++)

Cyan Option Description – The Cyan Option is offered as a variation to the Orange Option; the Red being an alternative to the Black and the Cyan an alternative to the Orange. The section which is new, and previously not described in full, is between the proposed Meifod (Bontnewydd) roundabout on the A487 and the unofficial bypass, into the Caeathro roundabout. In all other respects, the Cyan and Orange options share common alignments. For completeness, brief descriptions are given for the directionality of the WS 2+1 etc for both options separately and in full (i.e. chainage 0 to the end). The more detailed alignment reporting in this section describes only the section offered as a variation to the Black and Orange Options. The Cyan Option is the same as the Orange Option, and is 10.5km long.

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout, avoiding Gypsy Wood
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 10,460 Bypass of Crug and Pont Rug from Cibyn to the existing Plas Menai roundabout.

Appraisal Criteria	Assessment	Distribution	Significance
	approximately 1500 NSRs experiencing increases in road traffic noise as a result of the scheme due to the route being slightly shorter than that of the Red option.		
Local Air Quality	163 properties will experience an increase in PM_{10} and NO_2 respectively. 2730 properties will experience a reduction in PM_{10} and NO_2 respectively.	Benefits weighted towards the residents of Bontnewydd and Caernarfon.	Slight Beneficial (+)
Greenhouse Gas Emissions	CO_2 emissions – decrease of 522 tonnes in opening year. NPV of cost £1,748,000		Moderate Beneficial (++)
Landscape and townscape	Proposals include elements contradictory to existing topography and result in the loss of field patterns, boundaries and woodland. Embankment forms in particular introduce engineered elements into the rural landscape, whilst localised loss of woodland alters landscape character. The cutting at the Plas Menai tie-in also has a significant landscape and visual impact.	Welsh Highland Railway and Afon Seiont crossings in particular	Moderate Adverse (--)
Bio-diversity	There is a crossing of the Afon Gwyrfai which is designated as a SAC and SSSI, this is the most important feature potentially impacted upon. In this location there are potential impacts upon Otter, fish species, habitats, bat feeding sites etc. At the location where the Afon Gwyrfai is crossed there is relatively limited riparian habitat however so the impact would be reduced, also it is understood that the road would pass over the river at height with no structures in the river therefore reducing impacts. Also of particular significance is the crossing of the Afon Seiont, this does not have statutory designation but it, and the surrounding habitats are designated as Wildlife Sites (non-statutory) and represent a good mosaic of valuable habitats as well as supporting many of the important protected species that are also present in the Afon Gwyrfai. The location where this option crosses the	The most significant potential impacts are focused upon the Afon Gwyrfai and Afon Seiont with valuable habitats and protected species concentrated in these areas.	Moderate/Large Adverse (--/---)

Cyan Option Description – The Cyan Option is offered as a variation to the Orange Option; the Red being an alternative to the Black and the Cyan an alternative to the Orange. The section which is new, and previously not described in full, is between the proposed Meifod (Bontnewydd) roundabout on the A487 and the unofficial bypass, into the Caeathro roundabout. In all other respects, the Cyan and Orange options share common alignments. For completeness, brief descriptions are given for the directionality of the WS 2+1 etc for both options separately and in full (i.e. chainage 0 to the end). The more detailed alignment reporting in this section describes only the section offered as a variation to the Black and Orange Options. The Cyan Option is the same as the Orange Option, and is 10.5km long.

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout, avoiding Gypsy Wood
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 10,460 Bypass of Crug and Pont Rug from Cibyn to the existing Plas Menai roundabout.

Appraisal Criteria	Assessment	Distribution	Significance
	Afon Seiont has a potentially greater impact than the Purple and Yellow Options due to the more semi-natural form of the river and more extensive areas of woodland flanking the river at this location. Bats, Otters, Barn Owls, breeding birds, reptiles, amphibians, fish and Brown Hare are all likely to be impacted upon. The impact is considered to be Moderate adverse where both the Afon Gwyrfai and Afon Seiont are being crossed (this could be downgraded by careful mitigation and programming of works). Viewed in isolation there will be slight/moderate adverse impacts where a variety of Wildlife Sites are crossed, namely the Cae-rhydau, Afon Seiont Mosaic (South), Afon Seiont Mosaic (East), Maes Merddin and Afon Beuno Wildlife Sites. Collectively however the impact on the variety of habitats particularly those within designated sites increases the impact to moderate/large negative. The impact upon otters and bats is considered to be moderate and the impact is considered to be slight/moderate upon fish, Breeding birds and Badgers. The impacts are however generally slight adverse over much of the habitat to be impacted and other species. It is particularly recognised that parts of this option are on-line thus reducing impacts in comparison with the Purple and Yellow Options.	Significant impacts upon a number of Wildlife Sites collectively increase the overall impact. Potential impacts are generally much reduced over the majority of this option, although the impacts on Wildlife Sites and protected species, and particularly the widespread distribution of bats (especially Lesser Horseshoe Bats) needs particular consideration. The on-line sections reduce the impacts (although many	

Cyan Option Description – The Cyan Option is offered as a variation to the Orange Option; the Red being an alternative to the Black and the Cyan an alternative to the Orange. The section which is new, and previously not described in full, is between the proposed Meifod (Bontnewydd) roundabout on the A487 and the unofficial bypass, into the Caeathro roundabout. In all other respects, the Cyan and Orange options share common alignments. For completeness, brief descriptions are given for the directionality of the WS 2+1 etc for both options separately and in full (i.e. chainage 0 to the end). The more detailed alignment reporting in this section describes only the section offered as a variation to the Black and Orange Options. The Cyan Option is the same as the Orange Option, and is 10.5km long.

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout, avoiding Gypsy Wood
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 10,460 Bypass of Crug and Pont Rug from Cibyn to the existing Plas Menai roundabout.

Appraisal Criteria	Assessment	Distribution	Significance
		are at close proximity to Wildlife Sites).	
Heritage	No physical impact on SAMs. Two non-statutory archaeological sites subject to physical impact during road construction (buried section of Roman road, and Post-Medieval trackway). Major adverse impact upon the setting of one SAM and a Moderate adverse impact on the historic setting of two SAMs. Major adverse impact upon the historic setting of one Grade II* and three Grade II Listed Buildings. Moderate adverse impact upon the historic setting of one Grade II* and seven Grade II Listed Buildings. Potential impact upon new (i.e. undiscovered) archaeological sites is unknown, but is predicted as high in the northern part of the option corridor.	N/A	Large/Moderate Adverse (---/--)
Water environment	In general, the construction of new roadways through a 'greenfield' will increase surface water runoff, obstruct flood flow within the floodplain and cause a loss of flood plain storage if no mitigation measures are established. The crossing of the Afon Gwyrfai floodplain (via viaduct) will obstruct flood flow and cause a loss of flood storage and cannot be fully mitigated. Culverting 'main rivers' may also obstruct flood flow. General mitigation works include the attenuation of surface water runoff before discharging into watercourses, installing pollution control measures in high risk areas, crossing of watercourses to span the entire floodplain, and increasing culvert sizes at road crossings. The significance of effect has been determined for the design year and post-mitigation.	Afons Gwyrfai, Seiont, Cadnant and Rhyd.	Moderate Adverse (--)
Soils	The possible impact of contamination to the east of Cibyn Industrial Estate.	Cibyn Industrial Estate	Slightly Adverse

Cyan Option Description – The Cyan Option is offered as a variation to the Orange Option; the Red being an alternative to the Black and the Cyan an alternative to the Orange. The section which is new, and previously not described in full, is between the proposed Meifod (Bontnewydd) roundabout on the A487 and the unofficial bypass, into the Caeathro roundabout. In all other respects, the Cyan and Orange options share common alignments. For completeness, brief descriptions are given for the directionality of the WS 2+1 etc for both options separately and in full (i.e. chainage 0 to the end). The more detailed alignment reporting in this section describes only the section offered as a variation to the Black and Orange Options. The Cyan Option is the same as the Orange Option, and is 10.5km long.

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout, avoiding Gypsy Wood
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 10,460 Bypass of Crug and Pont Rug from Cibyn to the existing Plas Menai roundabout.

Appraisal Criteria	Assessment	Distribution	Significance
			(-)
Society			
Transport safety	Number of accidents saved: 3,573.7 – 2870.4 = 703.3 PVB = £172.2M – £139.7M = £32.5M The 2+1 carriageway standard provides safe overtaking opportunities.	All road users	Large Beneficial (+++)
Personal security		General population throughout Bontnewydd, Dinas Caernarfon and surrounding settlements.	Neutral (0)
Permeability	The bypass will substantially reduce community severance within the settlements of Bontnewydd and Dinas (+++) by reducing predicted traffic flows (AADT). It would also reduce severance to a lesser extent through Caernarfon (++). However, this relief from existing severance would be limited to the communities of Bontnewydd, Dinas and Caernarfon as other settlements, such as, Waunfawr, Llanrug or Bethel would not experience any significant relief from severance (0). Major beneficial overall.	Relief from severance limited to communities of Bontnewydd, Dinas and Caernarfon.	Large Beneficial (+++)
Physical Fitness	Without direct provision for cyclist and pedestrians, the bypass does nothing directly to encourage active modes of transport within Bontnewydd, Dinas or Caernarfon (0). However the reduction of congestion through Bontnewydd and Dinas may encourage more travel by active modes such as walking and cycling. The Orange Option will also affect seven public	General population throughout Bontnewydd, Dinas and	Slight Adverse (-)

Cyan Option Description – The Cyan Option is offered as a variation to the Orange Option; the Red being an alternative to the Black and the Cyan an alternative to the Orange. The section which is new, and previously not described in full, is between the proposed Meifod (Bontnewydd) roundabout on the A487 and the unofficial bypass, into the Caeathro roundabout. In all other respects, the Cyan and Orange options share common alignments. For completeness, brief descriptions are given for the directionality of the WS 2+1 etc for both options separately and in full (i.e. chainage 0 to the end). The more detailed alignment reporting in this section describes only the section offered as a variation to the Black and Orange Options. The Cyan Option is the same as the Orange Option, and is 10.5km long.

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout, avoiding Gypsy Wood
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 10,460 Bypass of Crug and Pont Rug from Cibyn to the existing Plas Menai roundabout.

Appraisal Criteria	Assessment	Distribution	Significance
	rights of way, NCN route 8 and another cycleway. Impacts on these will be most severe in the construction phase, however diversions will be provided as appropriate following construction. Despite diversions being put in place losses in amenity value of these routes may dissuade people from using them. Slight adverse overall (-)	Caernarfon and users of public rights of way.	
Social Inclusion	Although a full bypass solution will have beneficial effects in terms of social inclusion, increases in junction number onto the main road is unlikely to markedly increase accessibility contours and improve accessibly based upon criteria (+). Slight beneficial overall (+)	Populations west and south	Slight Beneficial (+)
Equality, Diversity & Human Rights	The Option is unlikely to have any impacts in relation to the race, ethnicity, colour or nationality, sex or marital status, disability: (physical, sensory or mental), age, religion or belief and sexual orientation (0). The provision of a new bypass does have the potential to encourage travel from non-Welsh speaking areas into this predominantly Welsh speaking area. This might lead to a dilution of the strong Welsh language culture within the area (-). Slight Adverse overall (-).	Potential impacts on strong Welsh language culture of the area.	Slight Adverse (-)
Transport Planning Objectives			
TPO 1	Moderate Beneficial (++) By 2016 journey time reduced by an average of 4 minutes throughout the day between Llanwnda and Plas Menai.		
TPO 2	Moderate Beneficial (++) By 2016 journey time reduced by an average of 4 minutes throughout the day between Llanwnda and Caernarfon.		
TPO 3	Moderate Beneficial (++) By 2016 the number of vehicles through Dinas along the A487 reduces by 82% based on 24hr AADT flow. By 2016 the number of vehicles through Caernarfon along the A487 reduces by 23% based on 24hr AADT flow.		
TPO 4	Large Beneficial (+++)		

Cyan Option Description – The Cyan Option is offered as a variation to the Orange Option; the Red being an alternative to the Black and the Cyan an alternative to the Orange. The section which is new, and previously not described in full, is between the proposed Meifod (Bontnewydd) roundabout on the A487 and the unofficial bypass, into the Caeathro roundabout. In all other respects, the Cyan and Orange options share common alignments. For completeness, brief descriptions are given for the directionality of the WS 2+1 etc for both options separately and in full (i.e. chainage 0 to the end). The more detailed alignment reporting in this section describes only the section offered as a variation to the Black and Orange Options. The Cyan Option is the same as the Orange Option, and is 10.5km long.

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout, avoiding Gypsy Wood
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 10,460 Bypass of Crug and Pont Rug from Cibyn to the existing Plas Menai roundabout.

Appraisal Criteria	Assessment	Distribution	Significance
	By 2016 accidents reduce by 54% along the A487. This meets the 22% reduction outlined in the TPOs.		
TPO 5	Large Beneficial (+++) Improved network resilience; by-pass provides a secondary route from north to south.		
Public acceptability:	Acceptable. Has wider benefits for communities of Bontnewydd, Dinas, Caernarfon, Caeathro and Bethel. A strategic link which would benefit wider public to a greater extent. Makes use of existing road corridor and provides further local connections with a link to the Cibyn Industrial Estate. Will adversely affect residents along existing "unofficial bypass". Significant impact upon Girl Guides property. Proximity to Kent Farm and Seiont nurseries and campsite. Reduces impact on Glan Gwna. 38 properties affected. Maintains traffic flow via Caeathro roundabout.		
Acceptability to other stakeholders:	Consultation undertaken with CCW to minimise environmental risks. Consultation with EA on flooding of Gwyrfai – structure modified to suit. CCW consulted on SAC and SSSI issues and confirmed western route of Bontnewydd acceptable. Consultation with Gwynedd Council required.		
Technical and operational feasibility:	Two relaxations in SSD. Flood relief structure over River Gwyrfai – significant structure for size of scheme. Welsh Highland Railway – likely some closure / possession required. Large structure over River Seiont in deep river valley. Caeathro Pont Rug road closed between Bontnewydd and Caeathro for 8 months during construction.		
Financial affordability and deliverability:	£7.1M/km. Could be built in phases.		

Cyan Option Description – The Cyan Option is offered as a variation to the Orange Option; the Red being an alternative to the Black and the Cyan an alternative to the Orange. The section which is new, and previously not described in full, is between the proposed Meifod (Bontnewydd) roundabout on the A487 and the unofficial bypass, into the Caeathro roundabout. In all other respects, the Cyan and Orange options share common alignments. For completeness, brief descriptions are given for the directionality of the WS 2+1 etc for both options separately and in full (i.e. chainage 0 to the end). The more detailed alignment reporting in this section describes only the section offered as a variation to the Black and Orange Options. The Cyan Option is the same as the Orange Option, and is 10.5km long.

Section 1 Ch 0 – 3,450 Bypass of Bontnewydd
Section 2 Ch 3,450 – 5,750 Bypass of Caernarfon connecting to existing Caeathro roundabout, avoiding Gypsy Wood
Section 3 Ch 5,750 – 7,250 Bypass of Caernarfon connecting to Cibyn Industrial Estate.
Section 4 Ch 7,250 – 10,460 Bypass of Crug and Pont Rug from Cibyn to the existing Plas Menai roundabout.

Appraisal Criteria	**Assessment**	**Distribution**	**Significance**
Risks:	Funding risks are known and are manageable. Consultation with GCC required. Flood modelling required at future stages.		
Comment:			

Appendix A.5 – Design Options Report Highways

A487 CAERNARFON TO BONTNEWYDD BYPASS

DESIGN OPTIONS REPORT HIGHWAYS

Welsh Government

3513874-PB-XX-XX-RP-J-00006

A487 Caernarfon to Bontnewydd Bypass

Design Options Report Highways

3513874-PB-XX-XX-RP-J-00006

Prepared for
Welsh Government
Sarn Mynach
Llandudno Junction
Conwy LL31 9RZ

Prepared by
Balfour Beatty/Jones Bros JV
Ty Glyn, Canol Y Dre
Ruthin LL15 1QW

Telephone 01824 703661

Report Title	:	**A487 Caernarfon to Bontnewydd Bypass Design Options Report Highways**
Doc Number	:	**3513874-PB-XX-XX-RP-J-00006**
Report Status	:	**Final**
Job No	:	**3513874A-HHC**
Date	:	**July 2015**

DOCUMENT HISTORY AND STATUS

Document control			
Prepared by	Matthew Godfrey	**Checked by** *(technical)*	Sharon Carr
Approved by	Russell Bennett	**Checked by** *(quality assurance)*	Kate Attwood

Revision details			
Version	**Date**	**Pages affected**	**Comments**
P1.0	12/06/15	All	First Issue
P2.0	22/07/15	All	Amended to reflect responses to Employer's Agent Comments
P3.0	07/10/15	All	Further amendments to reflect responses to Employer's Agent Comments

CONTENTS

		Page
1	**Executive Summary**	**1**
2	**The Project**	**8**
2.1	Context	8
2.2	Background	8
2.3	The Scheme	9
2.4	Project Objectives and Reason for Project	10
2.5	Purpose of Report	11
2.6	Option Appraisal	12
3	**Conceptual Design**	**13**
3.1	Environment	13
3.2	Highway	13
3.3	Structures	14
4	**Tender Design**	**16**
4.1	Option Identification	16
4.1.2	Tender Design Option T01 - Reduced 2+1 Standard	16
4.1.3	Tender Design Option T02 - Return to Agriculture	17
4.1.4	Tender Design Option T03 - Plas Menai Rock Cut	19
4.1.5	Tender Design Option T04 - Bypass Horizontal Alignment	21
4.1.6	Tender Design Option T05 - Bypass Vertical Alignment	23
4.2	Structures	25
4.2.1	Coverage	25
4.2.2	Tender Design Option T06 - Structure Verges	25
4.2.3	Tender Design Option T07 - Dinas Overbridge (S105)	26
4.2.4	Tender Design Option T08 - Pont Cefnwerthyd Underbridge (S108)	28
4.2.5	Tender Design Option T09 - Pont Ceriw Overbridge (S109)	28
4.2.6	Tender Design Option T10 - Relocate Pont Bryn Mafon (S111)	30
4.3	Drainage	32
4.3.1	Strategy	32
4.3.2	Tender Design Option T11 - Swale Drainage	32
4.3.3	Tender Design Option T12 - Over-Embankment Drainage	34
4.3.4	Tender Design Option T13 - Culvert Sizing	35
4.4	Value Engineering	37
4.4.1	Tender Design Option T14 - Parc Area Access	37
4.4.2	Tender Design Option T15 - FP19 Diversion	37
4.4.3	Tender Design Option T16 - A4085 Diversion	39
4.4.4	Tender Design Option T17 - Bethel Road Strategy	40
4.4.5	Tender Design Option T18 - Crug Farm Link Alternative	42
4.4.6	Tender Design Option T19 - Crug Lane Re-connection	44
4.4.7	Tender Design Option T20 - Plas Menai Left Filter	46
4.5	Tender Design Option Summary	47

4.5.1 Overall 47
4.5.2 Environment 48
4.5.3 Earthworks - Cuttings 48
4.5.4 Earthworks - Embankments 49
4.5.5 Highway Alignment 49
4.5.6 Overtaking Opportunity 49
4.5.7 WelTAG Appraisal 50
4.6 Departures from Standard 53
4.7 Risk 53

5 Preliminary Design 54
5.1 Option Identification 54
5.1.1 Preliminary Design Option P01 - Plas Menai Cut 54
5.1.2 Preliminary Design Option P02 - Removal of Return to Agriculture 56
5.1.3 Preliminary Design Option P03 - Landslip/Quarry Clearance 58
5.1.4 Preliminary Design Option P04 - Crug Farm Landtake 58
5.1.5 Preliminary Design Option P05 - Removal K=55 crests 61
5.1.6 Preliminary Design Option P06 - Side Road Section 62
5.1.7 Preliminary Design Option P07 - Reduced Road Lighting 65
5.1.8 Preliminary Design Option P08 - Removal of Underpass Lighting 66
5.2 Structures 68
5.2.1 Coverage 68
5.2.2 Preliminary Design Option P09 - Gwyrfai Viaduct Position (S106) 69
5.2.3 Preliminary Design Option P10 - Gwyrfai Viaduct Span (S106) 71
5.2.4 Preliminary Design Option P11 - Restore Dinas Underbridge (S105) 73
5.2.5 Preliminary Design Option P12 - Pont Cefnwerthyd Span (S108) 75
5.2.6 Preliminary Design Option P13 - Pont Ceriw Overbridge (S109) 78
5.3 Drainage 80
5.3.1 Strategy 80
5.3.2 Preliminary Design Option P14 - Culvert Sizing 81
5.3.3 Preliminary Design Option P15 - Highway Drainage Infiltration 84
5.4 Value Engineering 84
5.4.1 Preliminary Design Option P16 - Meifod Roundabout Relocation 84
5.4.2 Preliminary Design Option P17 - Re-connection of Crug Lane 86
5.4.3 Preliminary Design Option P18 - Re-connection of FP36 (S113A) 89
5.4.4 Preliminary Design Option P19 - Pengelli Isaf Farm Access (S114) 91
5.4.5 Preliminary Design Option P20 - Lay-by Provision 93
5.4.6 Preliminary Design Option P21 - Caerlan Tibot Culverts (S116 & S118) 97
5.4.7 Preliminary Design Option P22 - Seiont Viaduct Span (S112) 100
5.5 Preliminary Design Option Summary 102
5.5.1 Overall 102
5.5.2 Environment 103
5.5.3 Earthworks - Cuttings 103
5.5.4 Earthworks - Embankments 104
5.5.5 Highway Strategy 104

5.5.6 WelTAG Appraisal 105
5.6 Departures from Standard 109
5.7 Risk 109

6 Layout Approval 110
6.1 Design Proposals 110

Appendix A - Conceptual Design Drawings 111

Appendix B - Tender Design Drawings 111

Appendix C - Preliminary Design Drawings 111

Appendix D - Draft Layout Approval Plans 111

1 EXECUTIVE SUMMARY

1.1 Background and Context

1.1.1 The existing A487 is a single carriageway road in a rural location. The route is classified and maintained as a strategic trunk road by the North and Mid Wales Trunk Road Agency, on behalf of the Welsh Government, and experiences significant traffic congestion.

1.1.2 Congestion experienced in Caernarfon arises from increasing traffic volumes on the A487. This has resulted in community severance and reduced quality of life in settlements and dwellings adjacent to the A487, which are adversely affected by the high volumes of traffic passing through them.

1.1.3 In addition, the lack of high quality connectivity southwards on the A487 from Bangor and the A55 is seen to be hindering economic development in the region. The development of the Menai Hub provides an opportunity to strengthen and restructure the economy in North West Wales. However its successful implementation and dispersal of benefits is reliant on good quality transport links.

1.1.4 Extensive work has been undertaken to identify traffic problems in and around Caernarfon, Gwynedd, dating back to the early 1990's when a study to investigate possible bypass routes was commissioned by the Welsh Office to increase network capacity.

1.1.5 Following the investigation of route options and two public consultations, a Preferred Route (Purple Route) was recommended. This Preferred Route was announced by the Minister for Local Government and Communities in July 2012. A subsequent options review conducted for the Minister for Economy, Science and Transport designated the Yellow Route as the Preferred Route in May 2013.

1.1.6 The Yellow Option has been designated the Preferred route and the line has been protected from future development encroachment using a TR111. This will allow the further development of the scheme to improve the A487 around Caernarfon and Bontnewydd, whilst providing connections to the trunk road network east-west and north-south in line with 'One Wales: Connecting the Nation', 'The Wales Transport Strategy' and the 'National Transport Plan'.

1.1.7 In 2014, Welsh Government appointed Employer's Agent E C Harris and design consultant Ramboll to prepare the A487 Caernarfon to Bontnewydd Bypass scheme for ECI procurement, and in December 2014 a Balfour Beatty/Jones Brothers Joint Venture (JV) won the commission with designers WSP|Parsons Brinckerhoff and TACP.

1.2 The Scheme

1.2.1 The A487 Caernarfon to Bontnewydd Scheme involves the delivery of a primarily rural new highway, which is to be constructed off-line through a gently graded open landscape, largely characterised by scattered farms with associated field patterns and hedge boundaries. There are two significant river crossings over the Afon Gwyrfai and the Afon Seiont. The rural landscape through which the Scheme passes is characterised by extensive views inland to Snowdonia and to the Menai Straits and to Anglesey. The area also contains a number of designated sites of international, national and local biodiversity value. Of particular relevance are the Glynllifon Bats

Special Area of Conservation (SAC) and the Afon Gwyrfai SAC both of which have implications for structure design and provision.

1.3 This Report

1.3.1.1 At the request of the Employer the Design Options Report is to include a separate Structures Design Options Report. However, this Highways Design Options Report is an overarching report identifying the 'need' for all scheme elements, including structures, and appraising their impacts against WelTAG criteria.

1.3.1.2 This over-arching Highways Design Options Report considers the scheme as a whole within its geographical setting, summarises a description of the scheme at Conceptual Design (Key Stage 2), and reports on how the scheme has developed during the tender period up to the submitted Tender Design, and onwards through the early part of Key Stage 3 as a result of further design development, up to Preliminary Design.

1.3.1.3 The accompanying Structures Design Options Report reference 3513874-PB-XX-XX-RP-S-00001 concentrates on assessing the more detailed aspects of the different structural forms. These aspects are assessed against a number of more detailed assessment criteria and include items such as, but not limited to, buildability, local environment, function, whole life cost, aesthetics and effects on surrounding design elements.

1.3.1.4 The work undertaken to determine the optimum overall highway solution, with associated crossing points in relation to physical constraints, is covered in this Highways Design Options Report Highways*,* from which the need for particular structures to support the optimum solution is defined at a high level (i.e. the resulting need is simply defined as an overbridge, underbridge, viaduct, etc.).

1.3.1.5 Once the need for a structure has been defined, then there are a variety of structural solutions which could be developed to meet the particular need. These will typically involve consideration of different structural forms and structural materials.

1.3.1.6 This report outlines the background and source for each Tender Design and Preliminary Design option together with a full description, supported by an option sketch / drawing, plus the scope of any secondary effects the option may have on associated features.

1.3.1.7 The option appraisal has followed a three stage process:

i) Identification of option key features*;*
ii) Scoping against WelTAG key indicators and scheme TPO*;* and
iii) Workgroup appraisal summarised and significance assigned in Appraisal Summary Tables.

1.3.1.8 Each option was considered by a team comprising highway, environmental and transport planning specialists, in addition to a member of the contractor's team, and scored against the WelTAG indicators.

1.3.1.9 For each indicator, each option was scored according to the following WelTAG significance seven-point scale:

+ + +	Large beneficial

+ +	Moderate beneficial
+	Slight beneficial
0	Neutral
-	Slight adverse
- -	Moderate adverse
- - -	Large adverse

1.3.1.10 Each Tender Design option was compared against the Conceptual Design as its baseline, and each Preliminary Design option was compared against the Tender design as its baseline.

1.3.1.11 The appraisal of each option concludes with a summary of the key advantages/ disadvantages and a recommendation as to whether the option should be incorporated into the developing design.

1.4 Summary and Recommendations for Tender Design and Preliminary Design Options

1.4.1 The table below contains a summary of the design options considered as part of the scheme, and contains conclusions for those design options included at Tender, and recommendations for those design options that should be included in the Preliminary Design.

		Economy		Environment								Social						Transport Planning Objectives					Other Issues					
Ref	Option	Transport Economic Efficiency -TEE	Wider Economic Impacts - EALI	Noise	Local Air Quality	Greenhouse Gas Emissions	Landscape and Townscape	Bio-diversity	Heritage	Water Environment	Soils	Transport Safety	Personal security	Permeability	Physical Fitness	Social Inclusion	Equality, Diversity & Human Rights	TPO1 - Journey time / reliability Llanwnda to Plas Menai	TPO2 - Journey time / reliability Llanwnda to Caernarfon	TPO3 - Reduce vehicles in communities	TPO4 - Casualty reduction targets	TPO5 - Improve network resilience / capacity	Health impact	Stakeholder acceptability	Technical and operational feasibility	Affordability and deliverability	Risk	Adopt
T01	Reduced 2+1 Standard	0	0	0	0	0	0	+	0	0	+	-	0	0	0	0	0	0	0	0	-	-	0	-	0	+	-	×
T02	Return to Agriculture	0	0	0	0	0	+	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	+	-	✓
T03	Plas Menai Rock Cut	0	0	+	0	0	-	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	- -	✓
T04	Bypass Horizontal Alignment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	+	+	+	✓
T05	Bypass Vertical Alignment	0	0	0	0	0	+ +	+	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	+ +	0	✓
T06	Structure Verges	0	0	0	0	-	0	0	0	0	0	+	0	0	0	0	0	0	0	0	+	+	0	-	0	- -	+	×
T07	Dinas Overbridge (S105)	0	0	-	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	✓
T08	Pont Cefnwerthyd Underbridge (S108)	WelTAG appraisal curtailed																										×
T09	Pont Ceriw Overbridge (S109)	0	0	-	0	0	-	+	0	0	+	+	+	0	0	0	0	0	0	0	+	0	0	+	0	0	0	✓
T10	Relocate Pont Bryn Mafon (S111)	0	0	0	0	0	-	-	0	0	-	-	0	0	0	0	0	0	0	0	-	0	0	-	0	-	-	✓
T11	Swale Drainage	0	0	0	0	+	+	+	0	+	0	0	0	0	0	0	0	0	0	0	0	+	0	+	0	0	0	✓
T12	Over-Embankment Drainage	0	0	0	0	+	0	+	0	+	0	0	0	0	0	0	0	0	0	0	0	-	0	0	0	+	-	×

		Economy		Environment								Social						Transport Planning Objectives					Other Issues					
Ref	Option	Transport Economic Efficiency -TEE	Wider Economic Impacts - EALI	Noise	Local Air Quality	Greenhouse Gas Emissions	Landscape and Townscape	Bio-diversity	Heritage	Water Environment	Soils	Transport Safety	Personal security	Permeability	Physical Fitness	Social Inclusion	Equality, Diversity & Human Rights	TPO1 - Journey time / reliability Llanwnda to Plas Menai	TPO2 - Journey time / reliability Llanwnda to Caernarfon	TPO3 - Reduce vehicles in communities	TPO4 - Casualty reduction targets	TPO5 - Improve network resilience / capacity	Health impact	Stakeholder acceptability	Technical and operational feasibility	Affordability and deliverability	Risk	Adopt
T13	Culvert Sizing	0	0	0	0	0	0	- -	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	- -	0	+	-	×
T14	Access to Park Area	WelTAG appraisal curtailed																										×
T15	FP19 Diversion	0	0	0	0	0	0	+	0	0	0	-	+	0	0	0	0	0	0	0	-	+	0	0	+	+	-	✓
T16	A4085 Diversion	0	0	-	0	0	-	-	0	0	0	+	0	0	0	0	0	0	0	0	0	+	0	0	-	-	+	×
T17	Bethel Road Strategy	+ +	0	0	0	+	+	-	+	0	-	-	0	-	0	0	0	0	0	0	-	+	0	-	+	+ + +	-	✓
T18	Crug Farm Link Alternative	0	0	0	0	-	-	-	0	0	-	+	0	0	0	0	0	0	0	0	+	0	0	0	0	-	-	×
T19	Crug Lane Re-connection	- - -	+	-	0	-	- -	-	-	0	-	- -	0	0	0	+	0	0	0	-	-	+	0	-	- -	- - -	- -	×
T20	Plas Menai Left Filter	WelTAG appraisal curtailed																										×

		Economy		Environment								Social						Transport Planning Objectives					Other Issues					
Ref	Option	Transport Economic Efficiency -TEE	Wider Economic Impacts - EALI	Noise	Local Air Quality	Greenhouse Gas Emissions	Landscape and Townscape	Bio-diversity	Heritage	Water Environment	Soils	Transport Safety	Personal security	Permeability	Physical Fitness	Social Inclusion	Equality, Diversity & Human Rights	TPO1 - Journey time / reliability Llanwnda to Plas Menai	TPO2 - Journey time / reliability Llanwnda to Caernarfon	TP03 - Reduce vehicles in communities	TPO4 - Casualty reduction targets	TPO5 - Improve network resilience / capacity	Health impact	Stakeholder acceptability	Technical and operational feasibility	Affordability and deliverability	Risk	Adopt
P01	Plas Menai Cut	0	0	0	0	-	+ +	+	0	+	-	+	0	0	0	0	0	0	0	0	0	+	0	0	0	-	+	✓
P02	Removal of Return to Agriculture	-	0	0	0	0	-	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	✓
P03	Landslip/Quarry Clearance	WelTAG appraisal curtailed																										×
P04	Crug Farm Landtake	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	0	+	✓
P05	Removal K=55 crests	-	0	0	0	0	0	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0	0	+	0	0	+	✓
P06	Side Road Section	+	0	0	0	0	+	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0	0	+	0	+	0	✓
P07	Reduced Road Lighting	0	0	0	0	0	+	+	0	0	0	-	-	0	0	0	0	0	0	0	-	0	0	-	0	0	-	✓
P08	Removal of Underpass Lighting	0	0	0	0	0	0	+	0	0	0	0	-	0	0	-	0	0	0	0	0	0	0	+	0	0	0	✓
P09	Gwyrfai Viaduct Position (S106)	+	0	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	+	+	0	+ +	✓
P10	Gwyrfai Viaduct Span (S106)	+	0	+	0	0	+	0	0	-	-	0	0	0	0	0	0	0	0	0	0	+	0	-	+	+	- -	×
P11	Restore Dinas Underbridge (S105)	0	0	+	0	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	0	+	✓

		Economy		Environment								Social						Transport Planning Objectives					Other Issues					
Ref	Option	Transport Economic Efficiency -TEE	Wider Economic Impacts - EALI	Noise	Local Air Quality	Greenhouse Gas Emissions	Landscape and Townscape	Bio-diversity	Heritage	Water Environment	Soils	Transport Safety	Personal security	Permeability	Physical Fitness	Social Inclusion	Equality, Diversity & Human Rights	TPO1 - Journey time / reliability Llanwnda to Plas Menai	TPO2 - Journey time / reliability Llanwnda to Caernarfon	TP03 - Reduce vehicles in communities	TPO4 - Casualty reduction targets	TPO5 - Improve network resilience / capacity	Health impact	Stakeholder acceptability	Technical and operational feasibility	Affordability and deliverability	Risk	Adopt
P12	Pont Cefnwerthyd Span (S108)	+	0	0	0	+	0	-	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	-	+	+ +	-	✓
P13	Pont Ceriw Overbridge (S109)	+	0	0	0	0	0	+	0	0	-	+	0	-	+	0	0	0	0	0	0	0	+	0	+	+	-	✓
P14	Culvert Sizing	+	0	0	0	0	+	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	+	+	-	✓
P15	Highway Drainage Infiltration	WelTAG appraisal curtailed																										×
P16	Meifod Roundabout Relocation	0	0	0	0	0	+	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0	0	0	+	+	0	✓
P17	Re-connection of Crug Lane	- -	+ +	-	0	-	-	- -	-	0	-	-	0	0	0	+	0	0	0	0	0	0	0	- -	0	- -	-	✓
P18	Re-connection of FP36 (S113A)	-	0	0	0	-	0	+ +	0	+	-	+	-	+	+	+	0	0	0	0	+	0	+	+	-	-	+	✓
P19	Pengelli Isaf Farm Access (S114)	-	+	0	0	-	0	+	0	0	0	+	0	0	0	0	0	0	0	0	+	+	0	+	0	-	+	✓
P20	Lay-by Provision	+	0	0	0	0	+	0	0	0	+	+	0	0	0	0	0	0	0	0	0	+	0	-	0	+	-	✓
P21	Caerlan Tibot Culverts (S116 & S118)	+	0	0	0	+	+	-	0	-	+	0	0	0	0	0	0	0	0	0	0	+	0	0	-	0	-	✓
P22	Seiont Viaduct Span (S112)	+	0	+	0	0	+	0	0	0	-	0	0	0	0	0	0	0	0	0	0	+	0	-	+	+	- -	×

2 THE PROJECT

2.1 Context

2.1.1.1 Caernarfon is located on the Menai Straits which separates mainland Wales from Anglesey and is in the Welsh-speaking heartland of North Wales. Caernarfon has a population of just under 10,000. Caernarfon has experienced considerable growth, expanding beyond the medieval town walls and developing as the administrative centre of Gwynedd.

2.1.1.2 It is located on a coastal plain adjacent to a plateau to the banks of the Afon Seiont. It sits approximately 60 miles from the English border, 9 miles from Bangor to the north and 70 miles from Aberystwyth to the south.

2.1.1.3 The existing A487 is a single carriageway road in a rural location. The route is classified and maintained as a strategic trunk by the North and Mid Wales Trunk Road Agents, on behalf of the Welsh Government and experiences significant traffic congestion.

2.1.1.4 Congestion experienced in Caernarfon arises from increasing traffic volumes on the A487. This has resulted in community severance and reduced quality of life in settlements and dwellings adjacent to the A487, which are adversely affected by the high volumes of traffic passing through them.

2.1.1.5 To avoid the congested A487, adjacent substandard routes are being used as 'rat-runs' at inappropriate speeds. This in particular includes the Caeathro / Pont Rug road known locally as the 'unofficial bypass'.

2.1.1.6 The lack of high quality connectivity southwards on the A487 from Bangor and the A55 is seen to be hindering economic development in the region. The development of the Menai Hub provides an opportunity to strengthen and restructure the economy in North West Wales. However its successful implementation and dispersal of benefits is reliant on good quality transport links.

2.2 Background

2.2.1.1 Extensive work has been undertaken to identify traffic problems in and around Caernarfon, Gwynedd, dating back to the early 1990's when a study to investigate possible bypass routes was commissioned by the Welsh Office to increase network capacity.

2.2.1.2 The Welsh Assembly Government's Trunk Road Forward Programme 2002, as updated by the 2004 Supplement and reprioritised in 2008, determines and describes how growing demands for road transport would be met in the short and medium term.

2.2.1.3 Arup was commissioned in February 2007 by the Welsh Assembly Government to undertake a WelTAG Planning Stage and Stage 1 Study to consider transport issues and options in the Llanwnda to Plas Menai corridor using the draft version of WelTAG (May 2007). Broad options were generated during this commission including a bypass route and a combination of online measures and were recommended for further testing under the WelTAG Stage 1 Appraisal process. A Stage 1 Appraisal continued from the work undertaken in the A487 WelTAG Study, Planning Stage and Stage 1

Report with the aim to identify a select group of transport options for further testing under the WelTAG Stage 2 Appraisal.

2.2.1.4 Parsons Brinckerhoff (PB) and TACP were formally appointed by Transport & Strategic Regeneration (T&SR) of the Welsh Assembly Government (AG) to undertake the WelTAG Stage 2 A487 Caernarfon to Bontnewydd Study in February 2009. The result of this study recommended the Purple, Yellow, Black, Orange, Red and Cyan Options for a bypass, having similar AST scores and impacts across the range of the criteria in WelTAG, should all be presented as feasible solutions to the public as part of the stakeholder consultation process.

2.2.1.5 The WelTAG Stage 2 study included an initial public consultation that took place between March and May 2010 and a supplementary public consultation that took place between November 2010 and January 2011. The public consultations demonstrated clearly that the public accepted the need for improvements and that traffic conditions are the main cause of delayed journeys through Caernarfon and Bontnewydd.

2.2.1.6 Following the investigation of route options and two public consultations, a Preferred Route (Purple Route) was recommended. This Preferred Route was announced by the Minister for Local Government and Communities in July 2012. A subsequent options review conducted for the Minister for Economy, Science and Transport designated the Yellow Route as the Preferred Route in May 2013.

2.2.1.7 The Yellow Option has been designated the Preferred route and the line has been protected from future development encroachment using a TR111. This will allow the further development of the scheme to improve the A487 around Caernarfon and Bontnewydd, whilst providing connections to the trunk road network east-west and north-south in line with 'One Wales: Connecting the Nation', 'The Wales Transport Strategy' and the 'National Transport Plan'.

2.2.1.8 In 2014 Welsh Government appointed Employer's Agent EC Harris and design consultant Ramboll to prepare the A487 Caernarfon to Bontnewydd Bypass scheme for ECI procurement and in December 2014 a Balfour Beatty/Jones Brother Joint Venture (JV) won the commission with Designers Parsons Brinckerhoff (PB) and TACP.

2.3 The Scheme

2.3.1.1 The A487 Caernarfon to Bontnewydd Scheme involves the delivery of a primarily rural new highway, which is to be constructed off-line through a gently graded open landscape, largely characterised by scattered farms with associated field patterns and hedge boundaries. The new highway will connect from a new arm on the A499/A487 Goat Roundabout to a new arm on the A487 Plas Menai Roundabout junction.

2.3.1.2 The route shall be constructed to Wide Single 2+1 standards and achieve overtaking provisions as well as new laybys not less than those stated in the Key Stage 2 Technical Appraisal Report.

2.3.1.3 For the proposed alignment there are two significant river crossings over the Afon Gwyrfai and the Afon Seiont. The rural landscape through which the Scheme passes is characterised by extensive views inland to Snowdonia and to the Menai Straits and to Anglesey. The area also contains a number of designated sites of international, national and local biodiversity value. Of particular relevance are the Glynllifon Bats Special Area of Conservation (SAC) and the Afon Gwyrfai SAC.

2.4 Project Objectives and Reason for Project

2.4.1.1 The Welsh Government's (WG) 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''.

2.4.1.2 The Deputy First Minister and Minister for Economy and Transport, Ieuan Wyn Jones AM, published Wales' Transport Strategy, One Wales: Connecting the Nation, in May 2008 which replaced the 2001 Transport Strategy for Wales. The Strategy outlines the Welsh Government's plans to create an integrated transport network that meets the challenge of environmental sustainability whilst facilitating transport links to all of Wales.

2.4.1.3 The Strategy has the following key aims:

- Cutting transport emissions
- Joining up local transport
- Improving access to key communities and settlements
- Enhancing Wales' international connectivity
- Promoting safety and security

2.4.1.4 This also includes the Welsh Government's aim that by 2011 there will be a 3% cut in annual carbon-equivalent emissions in areas of devolved competencies.

2.4.1.5 The main aim of the Wales Transport Strategy was to create an integrated transport system as part of the One Wales commitments. The National Transport Plan is the mechanism by which the Welsh Government aims to integrate transport in Wales on a national scale. The draft national plan was published in July 2009 and sits alongside the regional transport plans in delivering the Transport Strategy.

2.4.1.6 The aims of the National Transport Plan are:

to meet the demand for enhanced mobility to enable economic growth and to improve the quality of life we seek for the people of Wales;
to put transport onto a more sustainable and less carbon-intensive path;
and to use transport funding more effectively in light of increasing pressures on public finances.

2.4.1.7 The project objectives, which form part of the Welsh Government's main transport policy aims, are to address the following traffic congestion problems:

- a lack of high quality road infrastructure hindering economic development of the area;
- community severance and quality of life for settlements along the A487;
- a high risk of collisions in urban areas;
- vehicles using county roads to bypass the A487; and
- difficulty in maintaining the trunk road due to high traffic levels and lack of suitable alternative routes.

2.4.1.8 The specific Scheme Transport Planning Objectives (TPO) are found in the Contract Documents Volume 2 Section 1.4 and are listed below. These objectives and the scheme meet the aims of the National Transport Plan and overall strategy for Wales:

TPO1	Reduce journey time (between Llanwnda and Plas Menai) and improve journey time reliability to within +/- 3 minutes of the average journey time throughout the day.
TPO2	Reduce journey time (between Llanwnda and Caernarfon) and improve journey time reliability to within +/- 3 minutes of the average journey time throughout the day.
TPO3	Reduce the number of vehicles passing through residential communities; including Llanwnda, Dinas, Bontnewydd and Caernarfon.
TPO4	Scheme to contribute to the Welsh Government casualty reduction targets: • 40% reduction by 2020; • 255 reduction in motorcyclists by 2020; and • 40% reduction in the number of young children killed or seriously injured by 2020.
TPO5	Improve network resilience – Increase the amount and/or capacity of alternative routes to improve the resilience of the network.

2.5 Purpose of Report

2.5.1.1 This Design Options Report is a requirement of the Works Information Volume 2, Clause 4.2.1 and its sub clauses. The report aims to document and appraise design development during Tender and Preliminary Design identifying the design changes applied to the Employer's Conceptual Design to arrive at the Preliminary Design proposal presented for Layout Approval purposes.

2.5.1.2 At the request of the Employer the Design Options Report is to include a separate Structures Design Options Report. However, this Highways Design Options Report is an overarching report identifying the 'need' for all scheme elements, including structures, and appraising their impacts against WelTAG criteria.

2.5.1.3 It should be noted that design development during the early part of Key Stage 3 is characterised by many parallel activities, and the production of an over-arching Design Options Report and a separate Structures Design Option Report is a reporting convenience which belies the complex and iterative interdependency between highway and structural solutions.

2.5.1.4 This over-arching Highways Design Options Report considers the scheme as a whole within its geographical setting, summarises a description of the scheme at Conceptual Design (Key Stage 2), and reports on how the scheme has developed during the tender period up to the submitted Tender Design, and onwards through the early part of Key Stage 3 as a result of further design development, up to Preliminary Design.

2.5.1.5 The accompanying Structures Design Options Report reference 3513874-PB-XX-XX-RP-S-00001 concentrates on assessing the more detailed aspects of the different structural forms. These aspects are assessed against a number of more detailed assessment criteria and include items such as, but not limited to, buildability, local environment, function, whole life cost, aesthetics and effects on surrounding design elements.

2.5.1.6 The work undertaken to determine the optimum overall highway solution, with associated crossing points in relation to physical constraints, is covered in this Highways Design Options Report Highways, from which the need for particular structures to support the optimum solution is defined at a high level (i.e. the resulting need is simply defined as an overbridge, underbridge, viaduct, etc.).

2.5.1.7 Once the need for a structure has been defined, then there are a variety of structural solutions which could be developed to meet the particular need. These will typically involve consideration of different structural forms and structural materials.

2.6 Option Appraisal

2.6.1.1 Each Tender Design and Preliminary Design option considered in this report is given a unique reference used throughout the report. The 'T' prefix series corresponds to options considered during tender development and 'P' prefix corresponds to Preliminary Design options leading to Layout Approval design.

2.6.1.2 This report outlines the background and source for each design option together with a full description, supported by an option sketch / drawing, plus the scope of any secondary effects the option may have on associated features.

2.6.1.3 The option appraisal has followed a three stage process:

iv) Identification of option key features;
v) Scoping against WelTAG key indicators and scheme TPO; and
vi) Workgroup appraisal summarised and significance assigned in Appraisal Summary Tables.

2.6.1.4 Each option was considered by a team comprising highway, environmental and transport planning specialists, in addition to a member of the contractor's team, and scored against the WelTAG indicators.

2.6.1.5 For each indicator, each option was scored according to the following WelTAG significance seven-point scale:

+ + +	Large beneficial
+ +	Moderate beneficial
+	Slight beneficial
0	Neutral
-	Slight adverse
- -	Moderate adverse
- - -	Large adverse

2.6.1.6 Each Tender Design option was compared against the Conceptual Design as its baseline, and each Preliminary Design option was compared against the Tender design as its baseline.

2.6.1.7 The appraisal of each option concludes with a summary of the key advantages/ disadvantages and a recommendation as to whether the option should be incorporated into the developing design.

3 CONCEPTUAL DESIGN

3.1 Environment

3.1.1.1 The Scheme is located on a low coastal plateau adjacent to the Menai Straits whilst inland it bounds the lower foothills of the Snowdon Massif which forms the basis for the Snowdonia National Park. The Scheme is dissected by a number of main watercourses and smaller streams. These include the Cadnant, Seiont and Gwyrfai; the latter being designated a Special Area of Conservation (SAC) under the EU Habitats Directive. In addition, the adjacent stretch of the Menai Straits forms part of the wider Conwy Bay SAC and to the north of the Scheme is the Glynllifon SAC, which is one of the largest Lesser Horseshoe Bat roosts in north west Europe. It is known from previous work that bats from this site fly in and around the Scheme area.

3.1.1.2 The Scheme area is given over primarily to pasture interspersed in areas with woodland, spinneys and hedgerow trees. This allows for extensive views both into and out of the Scheme area. Of particular importance is the effect on the setting of the Anglesey Area of Outstanding Natural Beauty (AONB) in the vicinity of the Plas Menai junction.

3.1.1.3 The conceptual scheme developed for the Key Stage 2 study gives only a broad indication as to the earthworks requirements and hence its “environmental” footprint. This tends to be on the conservative side resulting in the requirement for more extensive earthworks. The draft mitigation proposals reflect these in terms of screen and integration tree planting and indicative boundary requirements.

3.1.1.4 The extent of the Scheme and its potential effects on EU designated sites requires that both a statutory Environmental Impact Assessment (EIA) and Assessment on the Impact upon European Sites (AIES) are undertaken. These will identify effects and their significance and the relevant mitigation and compensation measures required to meet the statutory requirements.

3.1.1.5 The archaeological and heritage assets in the Scheme context include known and potential roman roads, post-medieval tracks, a milestone and a defensive enclosure at Caerlan Tibot (a Scheduled Ancient Monument). Anticipated impacts are both direct, from the Scheme footprint, and indirect, affecting visual context.

3.1.1.6 Mandatory Assumption 8 requires that all Rights of Way crossed by the route are to be maintained except FP36 which may be considered for stopping-up.

3.2 Highway

3.2.1.1 In addition to the project description, the Tender Documents mandated certain features of the Conceptual Design.

3.2.1.2 The route must:

- conform to the published Yellow Route TR111 (Mandatory Assumption 2);
- be formed of WS2+1 carriageway (Mandatory Assumption 4);
- with 2 lay-bys in each direction (Mandatory Assumption 16); and
- incorporating at-grade roundabouts (Mandatory Assumption 1).

3.2.1.3 Further details of the Conceptual Design are outlined in plan and long section drawings taken from the Key Stage 2 Technical Appraisal Report (TAR) Figures 16a to 16f. Both the Yellow Route TR111 and TAR figures are provided in Appendix A.

3.2.1.4 The original overtaking provision Mandatory Assumption 4 was inconsistent with Tender Documents Volume 2 referencing the 2+1 lane allocations detailed within the Stage 2 TAR as itemised in the table below. Revised Mandatory Assumption 4A modified the requirement to maximise overtaking equally in both directions.

		Northbound		Southbound	
Chainage	Location	Overtaking Length	Number of Lanes	Number of Lanes	Overtaking Length
0+000	Goat Roundabout		DAL	2	1.40km
0+250			1	2	
1+400			Non-conflicting crossover		
1+700		1.76km	2	1	
3+200			2	DAL	
3+460*	Meifod Roundabout				
3+530*			DAL	2	1.42km
3+700			1	2	
4+950			Non-conflicting crossover		
5+250		1.24km	2	1	
6+490*	Cibyn Roundabout				
6+560*		0.94km	2	1	
7+500			Conflicting crossover		
7+800			1	2	1.91km
9+710*	Plas Menai Roundabout				
		3.94km	**Total Overtaking Length**		**4.73km**

*roundabout chainages are as shown on the Conceptual Design drawings
DAL = Direct Acceleration Lane

3.2.1.5 Mandatory Assumption 5 requires the contractor to price for a Cement Bound Material (CBM) pavement and Mandatory Assumption 6 that a performance pavement foundation departure will be granted.

3.2.1.6 In addition to documenting the conceptual design the tender documents included site information for: land ownership, topographical survey and utilities. Nearing the end of the tender period a Tender Addendum updated the topographical survey information, from 5m to 1m contouring,

3.3 Structures

3.3.1.1 Conceptual Design structures were issued in the form of layout plans taken from the Key Stage 2 Technical Appraisal Report. The plans have conflicting referencing systems. To avoid confusion we have assigned the following unique structure references as used in this report and all scheme communications.

		Structure No.	
Name	Type	TAR	Tender
Ty Hên Underpass	Box culvert	Option 2.2 Structure 1	S101
Pont Parc Underpass			S101A*
Pont Afon Rhyd	Box culvert	Option 2.2 Structure 2	S102
Ty'n Llan Overbridge	3 span underbridge	Option 2.2 Structure 3	S103
Geufron Culvert	Pipe culvert	Option 2.2 Structure 4	S104
Dinas (Underpass)	Box underbridge	Option 2.2 Structure 5	S105
Pont Afon Gwyrfai	10 span viaduct	Option 2.2 Structure 6	S106
Pont Llydiart Gwyn	Box underbridge	Option 2.2 Structure 7	S107
Pont Cefnwerthyd	3 span underbridge	Option 2.2 Structure 8	S108
Pont Ceriw	Box underbridge	Option 2.2 Structure 9	S109
	Culvert		S110A*
Pen y Bryn Culvert	Pipe culvert	Option 1.4 Structure 1	S110
Pont Bryn Mafon	Box underbridge	Option 1.4 Structure 2	S111
Pont Afon Seiont Newydd	8 span viaduct	Option 1.4 Structure 3	S112
	Culvert		S112A*
Lôn Glai Overbridge	Single span overbridge	Option 1.8 Structure 1	S113
Afon Cadnant Culvert	Pipe culvert	Option 1.8 Structure 2	S114
Bethel Road Bridge	3 span underbridge	Option 1.8 Structure 3	S115
Caerlan Tibot Culvert	Pipe culvert	Option 1.8 Structure 4	S116
Crug Farm Overbridge	3 span overbridge	Option 1.8 Structure 5	S117
Crug Farm Culvert	Pipe culvert	Option 1.8 Structure 6	S118
	Culvert		S119*

* Added by tender addendum

Mandated Structures

3.3.1.2 The scope of the mandate for the Gwyrfai (S106) & Seiont (S112) viaducts was initially uncertain but tender clarification limited the mandate to length, carriageway width and level Mandatory Assumption 9A.

3.3.1.3 The bypass is also required to pass over the Welsh Highland Railway (S108). Mandatory Assumption 10.

3.3.1.4 Another tender inquiry resulted in Mandatory Assumption 14 to include for several missing culverts (S110A, S112A & S119).

3.3.1.5 Nearing the end of the tender period Mandatory Assumption 3 added a new structure, Pont Parc Underpass (S101A).

4 TENDER DESIGN

4.1 Option Identification

4.1.1.1 A workshop review of the scheme features identified those elements that might be modified during the Tender Design to better achieve the scheme objectives, whilst reducing programming constraints, and addressing ecological issues. Many options were discounted on initial appraisal and therefore were not progressed to the formal appraisal process documented by this report. The options detailed are mainly alternatives to the Conceptual Design, however a few endeavour to correct for deficiencies inherent in the Conceptual Design proposals.

4.1.2 Tender Design Option T01 - Reduced 2+1 Standard

4.1.2.1 Description

The mainline route conforms to what was during Key Stage 2 a newly developed Wide Single (WS) 2+1 highway standard formalised in the current TD 70/08. The standard mandates 3 no. 3.5m wide lanes, with a 1m median, and 1m hardstrips bounded by 2.5m soft verges to give a minimum 18.5m highway corridor before any earthwork and/or boundary treatments.

A number of alternative (departure) carriageway sections were considered to reduce the width of the highway corridor including; narrow lanes, reduced median and/or hardstrips and verge reduction. Due to vehicle safety and verge infrastructure issues only narrow (0.6m) hardstrips were considered a viable alternative.

T01 therefore considers the inclusion of a departure from standard for 0.6 hardstrips, thereby reducing the highway corridor to 17.7m wide.

4.1.2.2 Appraisal

Economy	**Assessment / Comment**	**Significance**
Transport Economic Efficiency -TEE	No impact	**0**
Wider Economic Impacts - EALI	No impact	**0**

Environment		
Noise	No impact	**0**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	No impact	**0**
Landscape and Townscape	No impact	**0**
Bio-diversity	Smaller footprint	**+**
Heritage	No impact	**0**
Water Environment	No impact	**0**
Soils	Less land	**+**

Society		
Transport Safety	Slight risk of collision to stationary vehicles	**-**
Personal security	No impact	**0**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	Slight increase in accident risk	**-**
TPO5 - Network resilience / capacity	More disruption from breakdown & reduced TM flexibility	**-**

Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	Landowner reduced landtake, WG departure, cyclist reps	**-**
Technical and operational feasibility	No impact	**0**
Affordability and deliverability	Reduced cost	**+**
Risk	No departure, PLI failure	**-**

4.1.2.3 Key advantages:

- Construction materials saving, especially pavement construction;
- Structure/culvert length saving;
- Reduced landtake & ecological footprint.

4.1.2.4 Key disadvantages:

- Departure from standard;
- Full width saving not always realised due to visibility requirements;
- VRS set-back issues especially at structures;
- Reduced maintenance TM flexibility;
- Reduced driver alert margin and breakdown/static vehicle passing safety;
- Reduced safety for cyclists.

4.1.2.5 Conclusion

Not incorporated in the Tender Design

4.1.3 Tender Design Option T02 - Return to Agriculture

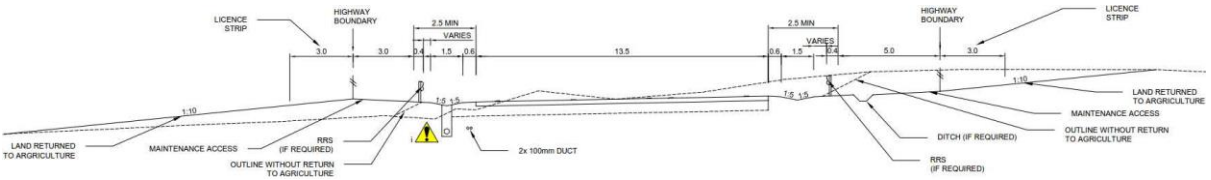
4.1.3.1 Description

During tender very only limited SI information was available. Supplementing this information with site visits and draft British Geological Society geology mapping it was resolved that there was insufficient data to modify the 1:2 side slopes shown in the Conceptual Design. However ground reprofilling of embankment / cutting slopes for return to agriculture was considered to manage the risk on the unknown volumes of

unsuitable materials and the risk associated with the unconfirmed side embankment slope angles.

Standard HA 55/92 advises that for the purposes of returning slopes to agriculture, the maximum slopes should be 1:4 for pasture and 1:10 for arable.

T02 therefore considered the inclusion of 1:10 slopes to return land to agriculture in appropriate locations without constraining future usage (see below or Drg.3513874-PB-XX-XX-DR-J-00001 in Appendix B).



4.1.3.2 Appraisal

Economy	**Assessment / Comment**	**Significance**
Transport Economic Efficiency -TEE	No impact	**0**
Wider Economic Impacts - EALI	No impact	**0**

Environment		
Noise	No impact	**0**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	No impact	**0**
Landscape and Townscape	Slight visual impact improvement	**+**
Bio-diversity	Removing existing hedgerows & habitats	**-**
Heritage	No impact	**0**
Water Environment	No impact	**0**
Soils	Impact on agricultural quality	**0**

Society		
Transport Safety	No impact	**0**
Personal security	No impact	**0**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	No change	**0**
TPO5 - Network resilience / capacity	No change	**0**

Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	Depends on landowner position	**0**
Technical and operational feasibility	Disposal on-site, earthworks 'float'	**+**
Affordability and deliverability	Reduced disposal costs, carbon footprint	**+**
Risk	Landowner acceptability	-

4.1.3.3 Key advantages:

- Embankment reduced visual intrusion;
- Re-profiling of side-hung ground to improve land drainage;
- Reduced off-site disposal;
- Earthwork balance flexibility.

4.1.3.4 Key disadvantages:

- Landtake by agreement;
- Constrained by fixed features; watercourses, established planting, roads;
- Disruption of topsoil stratigraphy.

4.1.3.5 Conclusion

Incorporated in the Tender Design in principle, however the extents required further development.

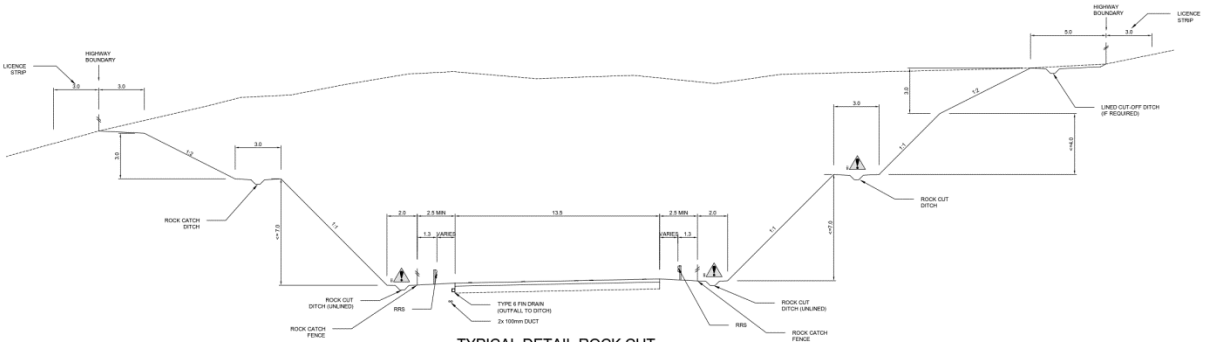
4.1.4 Tender Design Option T03 - Plas Menai Rock Cut

4.1.4.1 Description

The Conceptual Design used 1:2 slopes throughout. Due to the very limited tender ground investigation information these were considered appropriate for general slopes but excessive for the Plas Menai rock cut. Site visits and selected testing improved knowledge of rock properties suggesting a more appropriate rock cut profile.

T03 therefore considers a profile of 1:1 through the lower competent rock cut (maximum 7m lifts) with 3m wide drainage/maintenance berms between lifts. The upper 3m deep section could be 1:2 through the superficial material (see below or Drg.3513874-PB-XX-XX-DR-J-00001 in Appendix B).

A lower rock fall fence would be required at the base of the cut, enclosing a 2m wide strip and incorporating an open ditch, serving both to collect rock face run-off and adjacent highway drainage. It was agreed not to install a vehicle restraint system (VRS) as protection to the rock catch fence and ditch, unless it was required to protect against another hazard. It was noted that network practice in similar situations is to omit one or both of the rock catch fence / VRS combination.



4.1.4.2 Appraisal

Economy	**Assessment / Comment**	**Significance**
Transport Economic Efficiency –TEE	No impact	**0**
Wider Economic Impacts – EALI	No impact	**0**

Environment		
Noise	Noise constrained by narrower cutting	**+**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	No impact	**0**
Landscape and Townscape	Potential impact on Anglesey Area of Outstanding Natural Beauty	**-**
Bio-diversity	Different rock habitats	**+**
Heritage	No impact	**0**
Water Environment	No impact	**0**
Soils	Slight footprint reduction	**0**

Society		
Transport Safety	No impact	**0**
Personal security	No impact	**0**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	No change	**0**
TPO5 - Network resilience / capacity	No change	**0**

Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	No impact	**0**
Technical and operational feasibility	Increased maintenance	**-**
Affordability and deliverability	No impact	**0**
Risk	Anticipated rock cut is not in rock	**- -**

4.1.4.3 Key advantages:

- Reduced scheme landtake;
- Reduced cutting noise prorogation;
- Construction materials source security;
- Sustainability targets.

4.1.4.4 Key disadvantages:

- Increased reliance on SI identified rock properties;
- Increased visual intrusion Anglesey AONB;
- Additional rock processing operation;
- Increased rock fall hazard, including ditch maintenance.

4.1.4.5 Conclusion

Incorporated in the Tender Design.

4.1.5 Tender Design Option T04 - Bypass Horizontal Alignment

4.1.5.1 Description

A review of the scheme constraints and site visits indicated that changes to the horizontal alignment from the Conceptual Design might facilitate better accommodation of the site constraints and optimise delivery of the scheme objectives.

The published TR111 route and the limited margin for design relaxation made any major horizontal alignment changes very problematic and consequently only minor changes were considered.

The horizontal alignment changes considered by T04 were:

- A tighter left hand curve (reducing from 720m radius to 570m radius) at Ch.2+300 to remove transition from the Gwyrfai Viaduct (S106);
- A shorter left hand curve (by approximately 50m) at Ch.4+900 to move away from the quarry edge; and
- A longer right hand curve (by approximately 70m) at Ch.5+600 to remove the transition from the Seiont Viaduct (S112).

4.1.5.2 Appraisal

Economy	**Assessment / Comment**	**Signifi cance**
Transport Economic Efficiency -TEE	No impact	**0**
Wider Economic Impacts - EALI	No impact	**0**

Environment		
Noise	No impact	**0**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	No impact	**0**
Landscape and Townscape	No impact	**0**
Bio-diversity	No impact	**0**
Heritage	No impact	**0**
Water Environment	No impact	**0**
Soils	No impact	**0**

Society		
Transport Safety	No impact	**0**
Personal security	No impact	**0**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	No change	**0**
TPO5 - Network resilience / capacity	No change	**0**

Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	WG prefer straight bridges	**+**
Technical and operational feasibility	Easier build & maintain straight bridge, safety at quarry	**+**
Affordability and deliverability	Reduced structure costs	**+**
Risk	Reduced detailing mistakes	**+**

4.1.5.3 Key advantages:

- Simplified structure detailing reducing KS3 & KS6 costs;
- No additional departure requirement.

4.1.5.4 Key disadvantages:

- Based on un-confirmed tender topographical survey and preliminary structure proposals.

4.1.5.5 Conclusion

Incorporated in the Tender Design.

4.1.6 Tender Design Option T05 - Bypass Vertical Alignment

4.1.6.1 Description

As with the horizontal alignment, a review of the scheme constraints and site visits indicated a number of vertical alignment changes that might facilitate better accommodation of the site constraints and optimise delivery of the scheme objectives.

The vertical design approach was to replicate the Conceptual Design vertical design, but to drape the alignment over structure and other 'hard spot' features to minimise embankment and cutting heights. This would improve the earthworks balance and reduce the transport of materials.

The constraints provided by the side roads crossing over or under the Scheme were also considered, but these are explained in later design options in Section 3.4.

The vertical alignment changes included in T05 were:

- Higher alignment (by approximately 1m) at Ch.0+000 for improved Goat Roundabout tie-in;
- New sag curve at Ch.0+110 for reduced fill over S101;
- New sag curve at Ch.0+820 for enhanced headroom S103;
- Lower embankment (by approximately 4m) between Ch.1+100 to Ch.1+600 to facilitate an overbridge for S105;
- Raising the alignment by approximately 0.5m over the Gwyrfai Viaduct (S106) to maintain flood clearance;
- Moving the hog curve to the Welsh Highland Railway (Ch.2+720) to facilitate an overbridge for S109;
- Merging the double hog curve at Ch.4+050 to facilitate the online underbridge for S111;
- Lowering the alignment (by approximately 4m) between Ch.4+100 to Ch.4+700 to follow more closely the existing ground profile;
- Raising the alignment by approximately 4m over the Seiont Viaduct (S112) to maintain standard headroom over the A4085;
- Slacker gradient between Ch.5+600 to Ch.6+400 to follow more closely the existing ground profile;
- Various changes between Ch.7+100 to Ch.8+000 to follow more closely the existing ground profile and to reduce the impact on existing utilities;
- Delayed/deeper hog curve at Ch.8+150 and delayed/shallower crest curve at Ch.8+850 to follow more closely the existing ground profile and to facilitate an overbridge for S115;
- Delaying by approximately 100m the start of the 5% downgrade with the effect of shortening the climbing lane.

4.1.6.2 Appraisal

Economy	**Assessment / Comment**	**Significance**
Transport Economic Efficiency -TEE	No impact	**0**
Wider Economic Impacts - EALI	No impact	**0**

Environment		
Noise	No impact	**0**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	No impact	**0**
Landscape and Townscape	Reduced visual intrusion	**+ +**
Bio-diversity	Reduced footprint	**+**
Heritage	Reduced footprint	**+**
Water Environment	No impact	**0**
Soils	No impact	**0**

Society		
Transport Safety	No impact	**0**
Personal security	No impact	**0**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	No change	**0**
TPO5 - Network resilience / capacity	No change	**0**

Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	Reduced footprint, WG reduced cost, better landscape fit	**+**
Technical and operational feasibility	No impact	**0**
Affordability and deliverability	Reduced cost	**+ +**
Risk	No impact	**0**

4.1.6.3 Key advantages:

- Reduced materials requirement, transport and disposal (KS6 cost saving);
- Reduced embankment / cutting footprint and hence scheme landtake;
- Reduced visual impact, mainline more closely follows existing ground;
- Assists sustainability targets.

4.1.6.4 Key disadvantages:

- Minimum clearances reduce design flexibility e.g. drainage;
- Increased visual impact of ‘switched’ overbridges.

4.1.6.5 Conclusion

Incorporated in the Tender Design.

4.2 Structures

4.2.1 Coverage

4.2.1.1 A Structure Location Plan (14014-PB-17-ZZ-DR-S-0005) is provided in Appendix B and details of the Tender Design structure strategy are provided in the Structures Design Options Report (3513874-PB-XX-XX-RP-S-00001). This Highways Design Options Report does address structure type, dimension and location options derived from highway driven constraints.

4.2.1.2 For the purposes of this report structures are split into two sub-groups;

a) Viaducts, Overbridges, Underbridges, and Box Underbridges; and
b) Pipe and Box culverts.

The former are addressed in this section and listed in the table below, the latter are addressed in the Drainage section.

4.2.2 Tender Design Option T06 - Structure Verges

4.2.2.1 Description

The Conceptual Design included reduced verge widths across structures, with less than the widths required by TD27/05 and with no allowance for side road visibility splays to achieve TD9/93 standards. This design option includes widening the verges to full standard across structure verges to allow for the inclusion of kerb drainage, improved visibility and full VRS set-backs.

This would apply to all structures including mandated structures, general structures, and side road structures.

4.2.2.2 Appraisal

Economy	**Assessment / Comment**	**Significance**
Transport Economic Efficiency -TEE	No impact	**0**
Wider Economic Impacts - EALI	No impact	**0**

Environment		
Noise	No impact	**0**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	More concrete	**-**
Landscape and Townscape	No impact	**0**
Bio-diversity	No impact	**0**
Heritage	No impact	**0**
Water Environment	No impact	**0**
Soils	No impact	**0**

Society		
Transport Safety	Wider margin for breakdown/safety zone	**+**
Personal security	No impact	**0**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	Improved breakdown safety	**+**
TPO5 - Network resilience / capacity	Facilitates maintenance operations	**+**

Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	WG maintenance preference, cost disadvantage	**-**
Technical and operational feasibility	No impact	**0**
Affordability and deliverability	Increased cost	**- -**
Risk	Departure avoided	**+**

4.2.2.3 Key advantages:

- Departures avoided;
- Removes VRS set-back issues;
- Increased maintenance traffic management flexibility;
- Reduced driver alert margin and breakdown/static vehicle passing safety.

4.2.2.4 Key disadvantages:

- Construction materials increase;
- Structure/culvert length increase;
- Increased landtake & ecological footprint.

4.2.2.5 Conclusion

Not incorporated in the Tender Design.

4.2.3 Tender Design Option T07 - Dinas Overbridge (S105)

4.2.3.1 Description

To facilitate lowering of the mainline vertical alignment to reduce the fill requirement (Tender Design Option T05), it was necessary to change the Dinas Farm access from an underbridge to an overbridge.

This option would remove the need for a large cutting to provide access at either end of a lowered underbridge, that could also have resulted in drainage issues.

4.2.3.2 Appraisal

Economy	**Assessment / Comment**	**Significance**
Transport Economic Efficiency -TEE	No impact	**0**
Wider Economic Impacts - EALI	No impact	**0**
Environment		
Noise	Slight increase farm traffic noise	**-**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	No impact	**0**
Landscape and Townscape	Slight increase visual intrusion	**-**
Bio-diversity	No impact	**0**
Heritage	No impact	**0**
Water Environment	No impact	**0**
Soils	No impact	**0**
Society		
Transport Safety	No impact	**0**
Personal security	No impact	**0**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**
Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	No change	**0**
TPO5 - Network resilience / capacity	No change	**0**
Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	Landowner does not want overbridge	**-**
Technical and operational feasibility	No impact	**0**
Affordability and deliverability	No impact	**0**
Risk	Landowner opposition	**-**

4.2.3.3 Key advantages:

- Releases flexibility for earthwork optimisation;
- Less fill requirement in side road approaches than bypass embankment;
- Highway drainage can continue through structure.

4.2.3.4 Key disadvantages:

- Landowner preference for underbridge;
- Reduced bat flightpath connectivity;
- Additional structure costs over and above the cost of a box underbridge;
- Slight increase visual intrusion.

4.2.3.5 Conclusion

Incorporated in the Tender Design.

4.2.4 Tender Design Option T08 - Pont Cefnwerthyd Underbridge (S108)

4.2.4.1 Description

Welsh Highland Railway (WHR) had previously indicated that they may prefer their railway to pass over the bypass. This would have reduced the fill requirement due to the reduced embankment height.

This design option included assessing the design feasibility of a 1:50 railway vertical alignment to pass the Welsh Highland Railway over the reduced bypass vertical alignment.

4.2.4.2 Conclusion

The WelTAG appraisal was curtailed by Mandatory Assumption 10 requiring that the WHR must pass under the bypass. This option was therefore not incorporated in the Tender Design.

4.2.5 Tender Design Option T09 - Pont Ceriw Overbridge (S109)

4.2.5.1 Description

The Conceptual Design included the bypass on embankment in this location, with Pont Ceriw bridge passing underneath, off-line and to the north of, the side road's existing alignment. This underbridge would have formed an alignment 'hard spot' imposing a significant earthwork fill requirement.

This design option includes a change from an off-line underbridge to an on-line overbridge, requiring considerably reduced mainline embankment heights and side road embankment heights.

4.2.5.2 Appraisal

Economy	**Assessment / Comment**	**Significance**
Transport Economic Efficiency -TEE	No impact	**0**
Wider Economic Impacts - EALI	No impact	**0**

Environment		
Noise	Slight increase	**-**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	No impact	**0**
Landscape and Townscape	Slight visual intrusion	**-**
Bio-diversity	On-line reduced landtake	**+**
Heritage	No impact	**0**
Water Environment	No impact	**0**
Soils	Reduced landtake	**+**

Society		
Transport Safety	Improved side road visibility	**+**
Personal security	Slight benefit of overbridge	**+**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	Improved visibility reduces accident risk	**+**
TPO5 - Network resilience / capacity	No change	**0**

Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	Gwynedd straighter alignment, Landowner landtake	**+**
Technical and operational feasibility	Slight construction disruption	**0**
Affordability and deliverability	No impact	**0**
Risk	No impact	**0**

4.2.5.3 Key advantages:

- Facilitates earthwork optimisation;
- Reduced landtake;
- Improved visibility/safety.

4.2.5.4 Key disadvantages:

- On-line works construction disruption;
- Slight increase noise/visual intrusion.

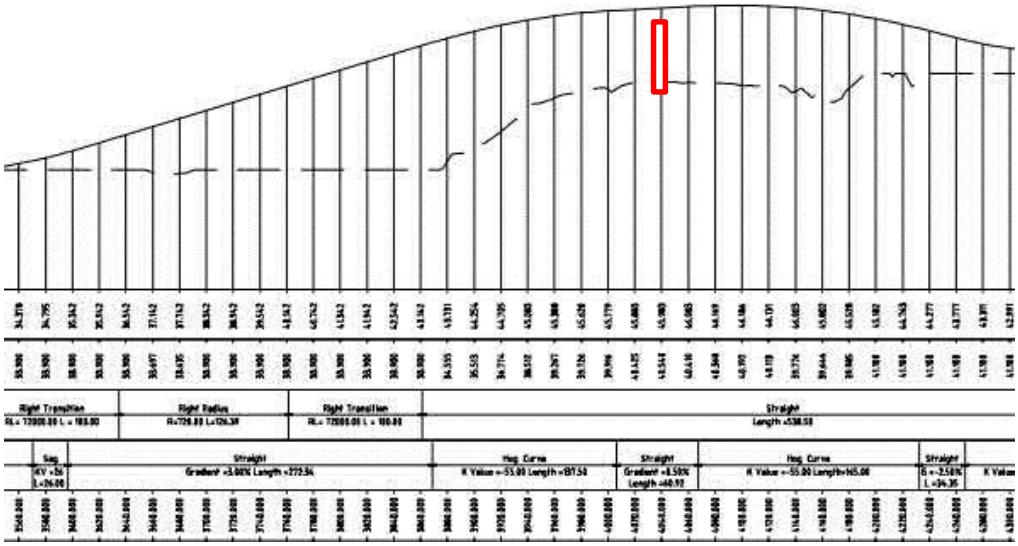
4.2.5.5 Conclusion

Incorporated in the Tender Design.

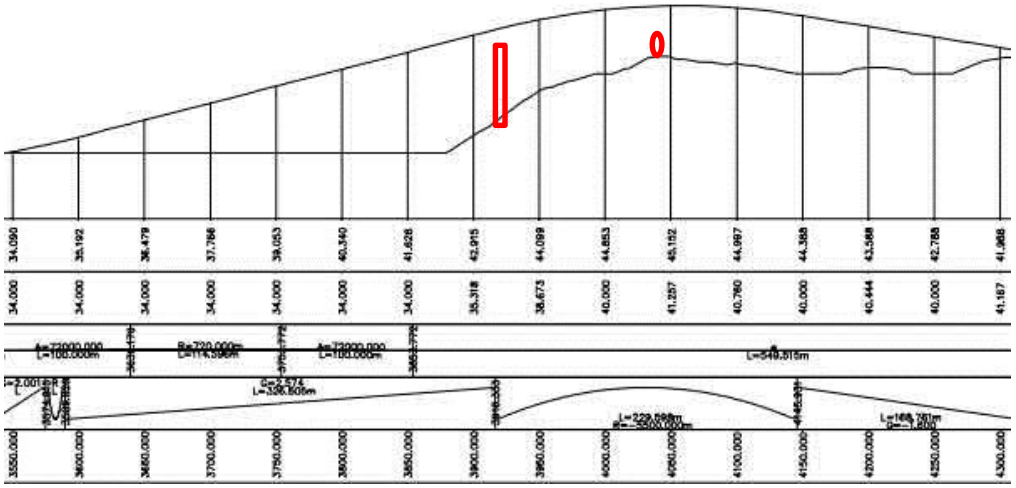
4.2.6 Tender Design Option T10 - Relocate Pont Bryn Mafon (S111)

4.2.6.1 Description

Again to facilitate lowering of the mainline vertical alignment to reduce the fill requirement (Tender Design Option T05), it was noted that Pont Bryn Mafon underbridge was locaqted on a landscape ridge (see extract of the Conceptual Design Figure 16c below).



By relocating the side road underpass downslope approximately 110m south, it would be possible to lower the mainline vertical alignment. The existing bat flightpath along Bryn Mafon could be retained through the introduction of a 1.8m diameter pipe (see extract of tender proposals below). Combined, these would reduce the vertical alignment by approximately 1m, plus enable the alignment to return to existing ground level more quickly, again reducing the fill requirement.



4.2.6.2 Appraisal

Economy	**Assessment / Comment**	**Significance**
Transport Economic Efficiency -TEE	No impact	**0**
Wider Economic Impacts - EALI	No impact	**0**
Environment		
Noise	No impact	**0**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	No impact	**0**
Landscape and Townscape	Slight impact for off-line route	**-**
Bio-diversity	Slight impact for off-line route	**-**
Heritage	No impact	**0**
Water Environment	No impact	**0**
Soils	Slight impact for off-line route	**-**
Society		
Transport Safety	Reduced visibility, increased accident risk	**-**
Personal security	No impact	**0**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**
Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	Slight increase accident risk due to visibility	**-**
TPO5 - Network resilience / capacity	No change	**0**
Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	Additional landtake,	**-**
Technical and operational feasibility	No impact	**0**
Affordability and deliverability	Increased cost	**-**
Risk	Gwynedd approval for off-line required	**-**

4.2.6.3 Key advantages:

- Facilitates earthwork optimisation;
- Enhanced dual bat/wildlife provision.

4.2.6.4 Key disadvantages:

- Additional pipe culvert costs;
- Additional landtake;
- Increased visibility/safety issues.

4.2.6.5 Conclusion

Incorporated in the Tender Design.

4.3 Drainage

4.3.1 Strategy

The Tender Design highway surface drainage strategy included over-the-shoulder run-off into a grassed verge swale, which, when full, discharged via a gridded catchpit to a carrier/filter drain beneath. The filter/carrier drain (with intermediate verge catchpits) then outfalled via a toe-of-earthwork attenuation pond designed to accommodate a 1 in 100 year storm, before outfalling via a 5 litre/s hydraulic throttle into the receiving watercourse.

Nominally sized attenuation ponds were provided at the following discharge points.

Ref.	Chainage	Ref.	Chainage	Ref.	Chainage
Pond 1	0+510	Pond 5	3+560	Pond 10	6+580
Pond 2	1+290	Pond 6	4+400	Pond 11	8+110
Pond 3	1+770	Pond 7	5+270	Pond 12	8+280
Pond 4	3+290	Pond 8	5+630	Pond 13	9+720
Pond 4a	2+130	Pond 9	6+440		

Highway sub-surface drainage at the head of the network was captured in a verge fin drain outfalling into the first filter/carrier pipe catchpit. Where the filter/carrier drain was already present, sub-surface drainage was via a sub-base extension to the filter/carrier drain.

Land drainage and natural catchment run-off was captured in un-lined cut-off ditches and routed to the nearest receiving watercourse. These ditches also served to receive embankment slope surface run-off where present.

The Conceptual Design's main river crossing structures and 2.1m diameter pipe culvert sizes were retained.

4.3.2 Tender Design Option T11 - Swale Drainage

4.3.2.1 Description

The highway drainage system included in the Conceptual Design was undefined but assumed to be a positive capture via gullies, discharging to a verge pipe and filter drain network.

This design option included the provision of over-the-shoulder highway drainage into a 1.5m verge swale with grassed 1:5 sides. When full, the swale would discharge via a gridded catchpit grid into the carrier/filter drain beneath.

4.3.2.2 Appraisal

Economy	**Assessment / Comment**	**Significance**
Transport Economic Efficiency -TEE	No impact	**0**
Wider Economic Impacts - EALI	No impact	**0**
Environment		
Noise	No impact	**0**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	No impact, reduced construction concrete	**+**
Landscape and Townscape	Hard materials removed	**+**
Bio-diversity	Improved wildlife habitat opportunities	**+**
Heritage	No impact	**0**
Water Environment	Water filtering by swale	**+**
Soils	No impact	**0**
Society		
Transport Safety	Kerbs deflect, swales allow run-over	**0**
Personal security	No impact	**0**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**
Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	No change	**0**
TPO5 - Network resilience / capacity	Reduced maintenance requirement	**+**
Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	WG/NMWTRA lower maintenance, sustainability target	**+**
Technical and operational feasibility	No impact	**0**
Affordability and deliverability	Reduced construction costs	**0**
Risk	No impact	**0**

4.3.2.3 Key advantages:

- Kerb & gully capital costs removed;
- Gully maintenance removed;
- Swale may pass over buried structure where clearance may prevent pipe;
- Improved silt/pollution mitigation in swale;
- Reduced water velocity, improved storm attenuation.

4.3.2.4 Key disadvantages:

- Swale occupies verge footprint, VRS/ducting positional constraints;
- Verge overrun may degrade swale performance;
- Increased verge maintenance.

4.3.2.5 Conclusion

Incorporated in the Tender Design.

4.3.3 Tender Design Option T12 - Over-Embankment Drainage

4.3.3.1 Description

Once collected in verge swales, this design option considered the potential to drain the highway run-off vertically through the embankment material and directly into existing ground through infiltration.

This would have removed the need for a carrier/filter drain network.

4.3.3.2 Appraisal

Economy	**Assessment / Comment**	**Significance**
Transport Economic Efficiency -TEE	No impact	**0**
Wider Economic Impacts - EALI	No impact	**0**

Environment		
Noise	No impact	**0**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	Reduced construction materials pipework	**+**
Landscape and Townscape	No impact	**0**
Bio-diversity	Slight increase wet habitat	**+**
Heritage	No impact	**0**
Water Environment	Slight sediment pollution advantage	**+**
Soils	No impact	**0**

Society		
Transport Safety	No impact	**0**
Personal security	No impact	**0**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	No change	**0**
TPO5 - Network resilience / capacity	Planned maintenance with pipes vs earthworks scour/slip	**-**

Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	WG/NMWTRA against, NRW for	**0**
Technical and operational feasibility	No impact	**0**
Affordability and deliverability	Reduced capital cost	**+**
Risk	Indeterminate maintenance liability	**-**

4.3.3.3 Key advantages:

- Avoids drainage pipe networks.

4.3.3.4 Key disadvantages:

- Potential for saturated soils to impact structural integrity;
- Sub-optimal infiltration causes embankment toe seepage;
- Potential seepage control / collection measures.

4.3.3.5 Conclusion

As a result of soakaway tests undertaken during the ground investigation works, it was determined that direct infiltration would not be viable.

This option was therefore not incorporated in the Tender Design.

4.3.4 Tender Design Option T13 - Culvert Sizing

4.3.4.1 Description

The culverts in the Conceptual Design were 2.1m diameter. This option considered the reduction in size of culverts where possible.

A sample hydraulic design identified that it would be possible to reduce culvert sizes to between 1.05m and 1.8m diameter.

4.3.4.2 Appraisal

Economy	**Assessment / Comment**	**Signifi cance**
Transport Economic Efficiency -TEE	No impact	**0**
Wider Economic Impacts - EALI	No impact	**0**

Environment		
Noise	No impact	**0**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	Minimal change construction materials	**0**
Landscape and Townscape	No impact	**0**
Bio-diversity	Impact on bat flightpaths and other wildlife	**- -**
Heritage	No impact	**0**
Water Environment	No impact	**0**
Soils	No impact	**0**

Society		
Transport Safety	No impact	**0**
Personal security	Potential requirement for safety grills	**0**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	No change	**0**
TPO5 - Network resilience / capacity	No change	**0**

Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	NRW & WG structures against	**- -**
Technical and operational feasibility	No impact	**0**
Affordability and deliverability	Slight cost reduction, easier to construct	**+**
Risk	NRW approval less likely	**-**

4.3.4.3 Key advantages:

- Reduced culvert costs;
- Vertical alignment flexibility for earthworks balance.

4.3.4.4 Key disadvantages:

- Impacts upon dual use for bat flightpaths / wildlife crossings;
- Reduced maintenance/inspection access;
- Increased blockage/trash maintenance risk.

4.3.4.5 Conclusion

Not incorporated in the Tender Design.

4.4 Value Engineering

4.4.1 Tender Design Option T14 - Parc Area Access

4.4.1.1 Description

Prior to instruction during tender to include Pont Parc Underpass (S101A), poor access to the Parc area was identified as a potential PLI objection source.

This option investigated existing side road provision and proposed mitigation to improve side road accessibility via overbridge S103. Three tight side road corners/junctions were identified as likely to hinder lorry access e.g. milk tanker, two of which were in the proximity of a SAM.

4.4.1.2 The WelTAG appraisal was curtailed by Mandatory Assumption 3 requiring that Pont Parc Underpass be provided at Ch.0+400

4.4.1.3 Conclusion

Improvements to side road accessibility not incorporated in the Tender Design.

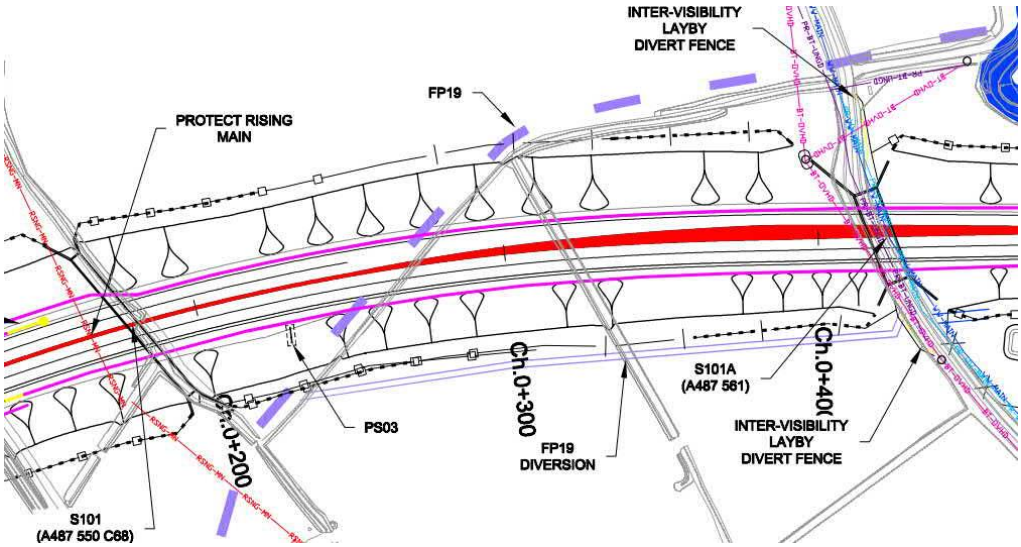
4.4.2 Tender Design Option T15 - FP19 Diversion

4.4.2.1 Description

As a result of the instruction during tender to incorporate Pont Parc Underpass (S101A), consideration was given to diverting FP19 through S101A, rather than through the dual use box culvert S101.

By diverting FP19 along the eastern fenceline until it reaches Parc side road, the footpath could then pass under the bypass mainline at S101A, as shown in the extract below.

This would permit the reduction in size of S101.



4.4.2.2 Appraisal

Economy	**Assessment / Comment**	**Significance**
Transport Economic Efficiency -TEE	No impact	**0**
Wider Economic Impacts - EALI	No impact	**0**
Environment		
Noise	No impact	**0**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	Pipe rather than box construction materials	**0**
Landscape and Townscape	No impact	**0**
Bio-diversity	Removal of lighting preferred by bats	**+**
Heritage	No impact	**0**
Water Environment	No impact	**0**
Soils	No impact	**0**
Society		
Transport Safety	Pedestrians in road	**-**
Personal security	NMU prefer overland route	**+**
Permeability	Slight reduction diversion length	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**
Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	Pedestrians in road	**-**
TPO5 - Network resilience / capacity	Reduced box underbridge maintenance / lighting	**+**
Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	WG/NMWTRA for cost/maintenance. Ramblers against	**0**
Technical and operational feasibility	Pipes easier, less design inputs	**+**
Affordability and deliverability	Reduced construction cost	**+**
Risk	Right of Way diversion on road not acceptable	**-**

4.4.2.3 Key advantages:

- Reduced cost S101 downsized from 3m x 3m box culvert to 2.1m diameter pipe;
- Avoids personal security risk in pedestrian underpass;
- Avoids pedestrian underpass lighting, improved for bats;
- Shorter diversion route.

4.4.2.4 Key disadvantages:

- Part of diversion on public highway.

4.4.2.5 Conclusion

Incorporated in the Tender Design.

4.4.3 Tender Design Option T16 - A4085 Diversion

4.4.3.1 Description

The Conceptual Design for the mandated Seiont viaduct (S112) included a sub-standard headroom to the existing A4085.

Consideration was given to a localised diversion of the A4085 offline and to the north, and down-slope to achieve the full standard headroom. The alignment of the A4085 side road would be lowered at the eastern end of the diversion, but the western end would run-out onto the existing side road due to the lower ground profile. On-line lowering of the A4085 was not viable due to major buried services within the highway boundary.

4.4.3.2 Appraisal

Economy	**Assessment / Comment**	**Significance**
Transport Economic Efficiency -TEE	No impact	**0**
Wider Economic Impacts - EALI	No impact	**0**

Environment		
Noise	A4085 receptors noise increase	**-**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	No impact	**0**
Landscape and Townscape	Slight impact off-line route	**-**
Bio-diversity	Removal of established trees	**-**
Heritage	No impact	**0**
Water Environment	No impact	**0**
Soils	Addition landtake, not good quality	**0**

Society		
Transport Safety	Reduced bridge bashing	**+**
Personal security	No impact	**0**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	Reduced impact accidents	**0**
TPO5 - Network resilience / capacity	Less maintenance / repair risk	**+**

Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	Glan Gwna against, Gwynedd for	**0**
Technical and operational feasibility	Increased construction activity	**-**
Affordability and deliverability	Slight cost increase	**-**
Risk	Removes headroom departure risk	**+**

4.4.3.3 Key advantages:

- Standard headroom achieved.

4.4.3.4 Key disadvantages:

- Additional landtake;
- Existing A4085 to be maintained for services.

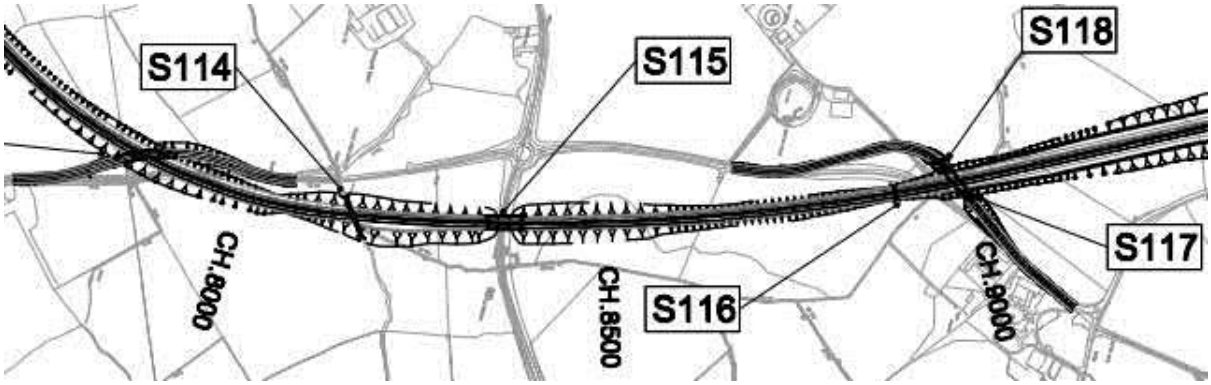
4.4.3.5 Conclusion

Not incorporated in the Tender Design.

4.4.4 Tender Design Option T17 - Bethel Road Strategy

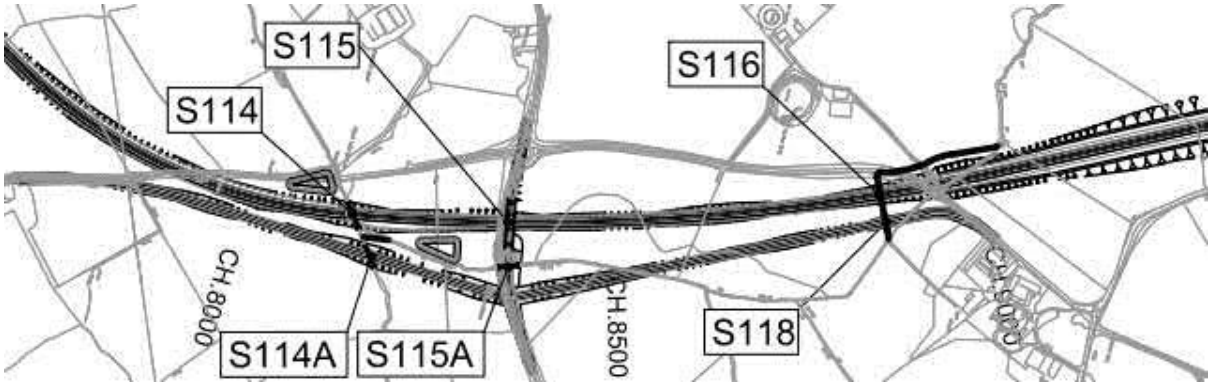
4.4.4.1 Description

In the Conceptual Design the existing side road passes west over the bypass on a high skew structure (S113) only to return east on a second high skew structure (S117) (see below). The Conceptual Design also included severe construction/safety issues due to the proximity of 132kV overhead cables and IP gas main in the vicinity of the southern abutment of S113.



This design option diverted the side road along the eastern side of the bypass with the introduction of a cross-roads junction with Bethel Road (see below). This avoided

the need for structures S113 & S117 and also lowered the bypass vertical alignment. The vertical alignment reduction permitted the exchange of Bethel Road underbridge (S115) for an overbridge (S115A).



4.4.4.2 Appraisal

Economy	**Assessment / Comment**	**Significance**
Transport Economic Efficiency -TEE	Reduction in scheme cost, 2 overbridges removed	**+ +**
Wider Economic Impacts - EALI	No impact	**0**

Environment		
Noise	Marginal, few receptors	**0**
Local Air Quality	Marginal	**0**
Greenhouse Gas Emissions	Reduction in concrete, increase in pavement	**+**
Landscape and Townscape	Less visual intrusion from overbridges	**+**
Bio-diversity	Impact on marshland habitat	**-**
Heritage	Move away from Scheduled Ancient Monument improves setting	**+**
Water Environment	Ditch culverting / training	**0**
Soils	More landtake	**-**

Society		
Transport Safety	Cross-road safety, low flows bypass capture of N-S traffic	**-**
Personal security	No impact	**0**
Permeability	Pengelli Farm severed	**-**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	Cross-road visibility / safety	**-**
TPO5 - Network resilience / capacity	Reduce maintenance structures & side road	**+**

Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	Pengelli Isaf farm against, WG/NMWTRA & CADW for	**-**
Technical and operational feasibility	Improved utilities safety, long beam delivery/craneage	**+**
Affordability and deliverability	Reduced cost	**+ + +**
Risk	PLI objection	**-**

4.4.4.3 Key advantages:

- Capital cost / structure maintenance saving;
- Improved construction safety, reduced working in vicinity of utilities;
- Significant programme advantages by avoiding need to divert utilities that would have very long lead in times;
- Reduced visual intrusion, bypass lowered;
- Reduced impact upon Scheduled Ancient Monument.

4.4.4.4 Key disadvantages:

- Potential PLI objection Pengelli Isaf farm;
- Increased side road works, Gwynedd Council approval required;
- Landtake in wetland habitat;
- Abandonment of existing highway assets.

4.4.4.5 Conclusion

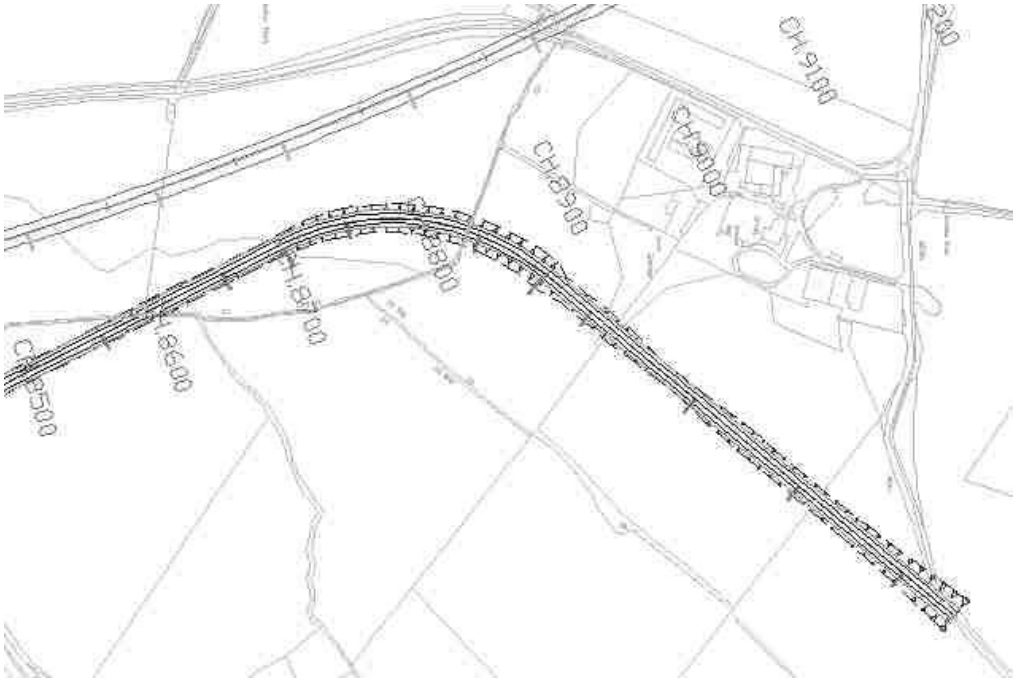
Incorporated in the Tender Design.

4.4.5 Tender Design Option T18 - Crug Farm Link Alternative

4.4.5.1 Description

The existing Crug Lane to the north of Crug Farm is constrained by a wall to south and vegetation/ditch to the north, such that the narrow carriageway does not readily accommodate passing of increased HGV traffic to/from Delsol, as a result of the closed Crug Lane link into Plas Menai Roundabout.

By realigning the side road in Tender Design Option T17, it permitted the consideration of relocating Crug Lane to the rear (south) of Crug Farm (see below). This option would have provided full standard access for Delsol traffic onto Bethel Road and whilst the existing Crug Lane immediately in front (north) of the property could have been retained for access only (no through road).



4.4.5.2 Appraisal

Economy	**Assessment / Comment**	**Significance**
Transport Economic Efficiency -TEE	No impact	**0**
Wider Economic Impacts - EALI	No impact	**0**

Environment		
Noise	No impact, possible receptor location issue	**0**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	More pavement, construction materials	**-**
Landscape and Townscape	Visual impact new corridor	**-**
Bio-diversity	Impacts on marshland habitats	**-**
Heritage	No impact	**0**
Water Environment	No impact	**0**
Soils	Additional landtake	**-**

Society		
Transport Safety	Oncoming traffic accidents reduced	**+**
Personal security	No impact	**0**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	Marginal reduction	**+**
TPO5 - Network resilience / capacity	No change	**0**

Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	Crug Farm / Delsol assumed support, Gwynedd against	**0**
Technical and operational feasibility	No impact	**0**
Affordability and deliverability	Slight additional cost	**-**
Risk	Crug farm PLI objection	**-**

4.4.5.3 Key advantages:

- Reduced impact established highway boundaries;
- Improved highway standards / safety.

4.4.5.4 Key disadvantages:

- Gwynedd Council approvals required;
- Visual impact new corridor;
- Potential noise receptor issues, rear Crug Farm;
- Additional landtake.

4.4.5.5 Conclusion

Not incorporated in the Tender Design.

4.4.6 Tender Design Option T19 - Crug Lane Re-connection

4.4.6.1 Description

The Conceptual Design stopped up the northern section of Crug Lane preventing its connection to the Plas Menai Roundabout. Due to potential objections Crug Farm plant nursery and Delsol distribution businesses, consideration was therefore given to retaining a one-way connection to Crug Lane by including a diverge from the southbound bypass on the initial part of the climbing lane.

Once diverged, it would gradually climb on a berm in the Plas Menai cutting until it reconnected with the existing Crug Lane.

This would be combined with the retention of the de-commissioned northbound side road near the Scheduled Ancient Monument to provide an illuminated northbound merge onto the bypass, allowing Bethel Road traffic to join the bypass northbound.

This option would eventually become Option 4A in the Crug Lane Options Report (3513874-PB-XX-XX-RP-J-00012).

4.4.6.2 Appraisal

Economy	**Assessment / Comment**	**Significance**
Transport Economic Efficiency -TEE	Significant capital cost increase, low existing traffic demand, low time savings	**- - -**
Wider Economic Impacts - EALI	Easier business/customer access, may attract new business	**+**

Environment		
Noise	Increased impact for existing few local receptors	**-**
Local Air Quality	A few existing local receptors	**0**
Greenhouse Gas Emissions	Increased excavation and processing of construction materials	**-**
Landscape and Townscape	Widened cutting landscape impact, slight increase lighting scheme	**- -**
Bio-diversity	Potential bat impacts	**-**
Heritage	Potential archaeology impact	**-**
Water Environment	No change on baseline scheme	**0**
Soils	Slight additional landtake	**-**

Society		
Transport Safety	Atypical junction, non-standard weaving, driver non-compliance one-way, driver confusion and vehicle restraint challenge	**- -**
Personal security	No change on baseline scheme	**0**
Permeability	Limited change on baseline scheme	**0**
Physical Fitness	No change on baseline scheme	**0**
Social Inclusion	Slight improvement access to Trunk Road and hence services	**+**
Equality, Diversity & Human Rights	No change on baseline scheme	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	Marginal additional traffic Bethel Road & Crug Lane	**-**
TPO4 - Casualty reduction target	Asymmetrical junctions incur additional accident risk	**-**
TPO5 - Network resilience / capacity	Junctions add network management opportunity	**+**

Other Issues		
Health impact	No change on baseline scheme	**0**
Stakeholder acceptability	Crug Farm / Delsol assumed OK. Reduced risk Gwynedd Council objection	**-**
Technical and operational feasibility	Split level rock cut and VRS provision, merge geometry	**- -**
Affordability and deliverability	Significant additional cost, some technical challenges	**- - -**
Risk	Environmental impact, PLI objection, departure deliverability	**- -**

4.4.6.3 Key advantages:

- Reduces PLI objection risk by Crug Farm / Delsol;
- Mostly uses existing infrastructure / highway corridors.

4.4.6.4 Key disadvantages:

- Additional cost, especially increased excavation Plas Menai cutting;
- Increased lighting potential bat flightpath impacts;
- Increased visual intrusion Anglesey Area of Outstanding Natural Beauty from wider Plas Menai cut;
- Poor (departure) standards at Plas Menai cutting diverge;
- Safety issues asymmetric / atypical bypass junctions;
- Bethel Road / Bypass connection not Gwynedd Council preference.

4.4.6.5 Conclusion

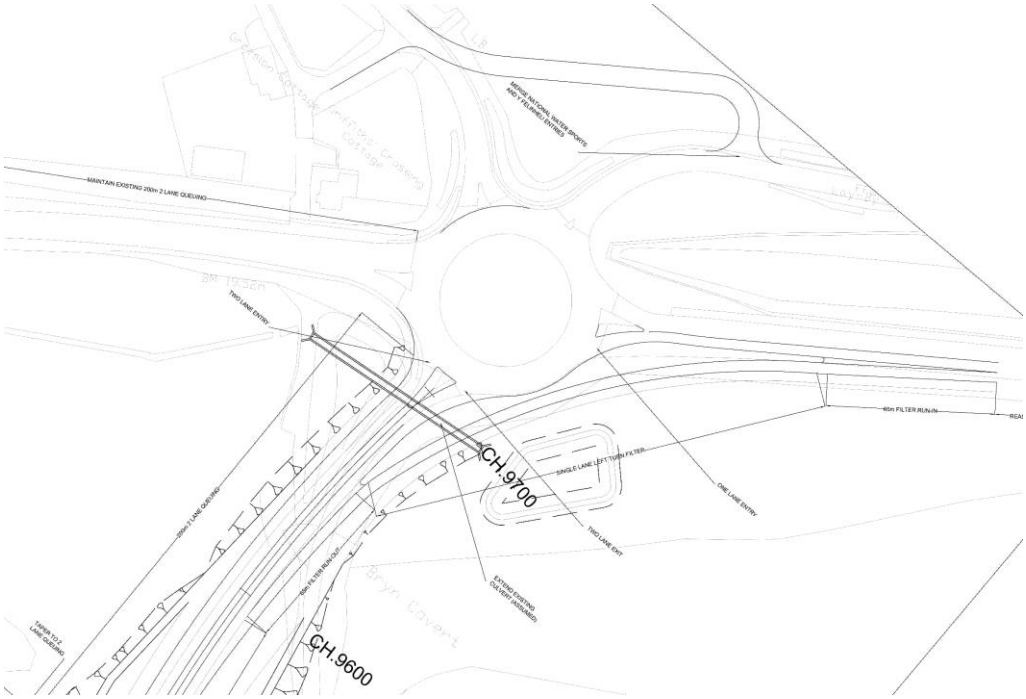
Not incorporated in the Tender Design.

4.4.7 Tender Design Option T20 - Plas Menai Left Filter

4.4.7.1 Description

Mandatory Assumption 12 required that tenderers allow for geometric design of Plas Menai Roundabout to accommodate revised traffic movements following connection of the bypass and severance of Crug Lane. Initial traffic appraisal work undertaken using the Key Stage 2 traffic model indicated that the roundabout may require remodelling works over-and-above the addition of the bypass connection, to prevent traffic congestion.

Consideration was therefore given to introducing a dedicated left filter to allow south-west bound A487 traffic dedicated entry onto the bypass, and merging of the yacht club and Y- Felinheli links, to improve performance of the roundabout (see below).



Reworking of the Key Stage 2 traffic model showed that the Plas Menai traffic flows were not as high as originally predicted. In addition, the SATURN junction performance analysis showed that the existing roundabout layout, with the addition of a simple bypass connection, would achieve adequate design year performance.

4.4.7.2 Conclusion

As a result of the SATURN traffic performance modelling showing additional roundabout works not required, the WelTAG appraisal was curtailed and the design option was not incorporated in the Tender Design.

4.5 Tender Design Option Summary

4.5.1 Overall

4.5.1.1 The key features of the design as reflected in the Tender Design drawings (Appendix B) are:

- Horizontal alignment as published TR111;
- Vertical alignment optimised for earthworks balance, generally lowered;
- Plas Menai 1:1 rock cut profile, 1:2 slopes elsewhere;
- Dinas underbridge changed to overbridge as a result of mainline vertical alignment reductions;
- Pont Ceriw underbridge changed to overbridge;
- Pont Bryn Mafon underbridge re-located;
- Side roads at Bethel Roads switched to east, 2 structures removed;
- FP19 diverted, FP36 severed.

4.5.2 Environment

4.5.2.1 The landscape design developed for the tender design took into account the following key objectives set out in paragraph 1.2.1 of Appendix D, Volume 2A of the Works Information:

- Retain and make best use of existing vegetation;
- Prioritise the early re-establishment of vegetation within the highway boundary;
- Integration of the engineering landform with the adjoining topography;
- Designing for maintenance, consideration of the maintenance costs & implications, liabilities and access arrangements;
- Optimise protection for nearby houses or public areas through use of screening, including vegetative and structural methods;
- Avoid loss or damage to any designated or protected landscape features;
- Avoid loss or damage to landscape features, e.g. cloddiau/ hedges / hedgerows/ hedgebanks/ drystone walls, individual and veteran trees, woodland, water features, or field systems where possible within the constraints of the design;
- Consider innovative solutions for integrating hard structures into the landscape setting of the scheme;
- Use of suitable and appropriate boundary treatments.

4.5.2.2 In addition the wider environmental mitigation took into account the perceived effects and the results of the Key Stage 2 study.

4.5.2.3 In more detail particular attention was given to a number of features. First of these was the mitigation developed for bats, in particular the Lesser Horseshoe bat. The Scheme area has been described as a “bat landscape” and therefore every effort was made to mitigate the effects of the Scheme on the bat population and its activities. This included the use of oversized culverts throughout the Scheme including specific structures for bats to move through the Scheme (e.g. S111A). This was supported by the use of temporary fencing to guide the bats during construction whilst mitigation planting becomes established together with the retention of existing vegetation to supplement new planting.

4.5.2.4 This approach also incorporated provision for otters in the area with culverts having a multi-function role. Otter-proof fencing was provided to help guide the animals to the crossing points.

4.5.2.5 The tender proposals also took on board the requirements of the EU Water Framework Directive. Essentially these are concerned with water quality, biological quality and the use of soft engineering in terms of drainage design. The Tender Design made extensive use of grass swales for primary drainage adjacent to the road and these were supported by a system of balancing ponds to control flow. In addition all culverts which include water courses had bioengineered bases to allow for fish to pass through the structures.

4.5.3 Earthworks - Cuttings

4.5.3.1 In the Tender Design, the earthworks design profile for the cuttings, excluding the Plas Menai Cutting, was based on extremely limited published geological information, (the most recent British Geological Society mapping being dated 1852), no intrusive ground investigation, and unpublished data. The Tender Design adopted the Conceptual Design assumption of 1:2 slopes through the cuttings, which were largely to be within glacial till materials. It was assumed for tender that the shear strength of

the superficial deposits would be sufficient for the proposed side slopes to remain stable without any additional engineering.

4.5.4 Earthworks - Embankments

4.5.4.1 In the Tender Design, the earthworks design profile for the side slopes of the embankments adopted the Conceptual Design for 1:2 side slopes. This was based upon unpublished information that identified a number of areas as having weak and/or compressible ground beneath the proposed earthworks. An allowance was made in these areas to excavate up to 1.0m of the weak and compressible soils and replace with suitable granular fill.

4.5.5 Highway Alignment

4.5.5.1 Early review of the Conceptual Design earthworks revealed a potential fill deficit and significant haul distances hindering cost effective and minimally disruptive construction. Much of the bypass alignment development during tender was focused on reducing earthworks volumes, minimising haul distances, eradicating the need for import of materials, and eradicating the need for haulage on the public highway. A further earthworks objective was to obtain the majority of premium aggregates through on-site processing of rock won from the Plas Menai cutting.

4.5.5.2 Specific Tender Design alignment changes are considered in Tender Design Options T04 & T05 but in essence the published TR111 (May 2013) horizontal alignment was generally retained whilst the vertical alignment was amended.

4.5.5.3 The vertical alignment was lowered to minimise the height of the embankments and cuttings. It was essentially ‘draped’ over the ‘hardspots’ caused by structures and other tie-ins, so as to achieve an earthworks balance with reduced mass haulage of materials.

4.5.6 Overtaking Opportunity

4.5.6.1 As outlined in Section 2.2, Mandatory Assumption 4A required the provision of overtaking opportunities as offered by the 2+1 standard. The Conceptual Design appeared to include directionally biased opportunity, contrary to Mandatory Assumption 4A so we undertook a review at tender stage to redress the imbalance. The table below gives the revised overtaking opportunity as proposed by the review.

		Northbound		Southbound	
Chainage	Location	Overtaking Length	Number of Lanes	Number of Lanes	Overtaking Length
0+000	Goat Roundabout		DAL	2	1.65km
0+250			Taper	2	
0+380			Shift	2	
0+520			1	2	
1+650			Non-conflicting crossover		
1+700		1.76km	2	1	
2+990			2	Shift	
3+130			2	Taper	
3+260			2	DAL	
3+460	Meifod Roundabout				
3+530			DAL	2	1.42km
3+830			Taper	2	
3+960			Shift	2	
4+100			1	2	
4+950			Non-conflicting crossover		
5+000		1.49km	2	1	
5+970			2	Shift	
6+110			2	Taper	
6+240			2	DAL	
6+490	Cibyn Roundabout				
6+560		1.35km	2	1	
7+910			Conflicting crossover		
8+210			1	2	1.50km
8+590	Climbing lane		1	2	
9+710	Plas Menai Roundabout				
		4.60km	**Total Overtaking Length**		**4.57km**

DAL = Direct Acceleration Lane

4.5.7 WelTAG Appraisal

4.5.7.1 The following table includes a summary of WelTAG significant assessment for all the Tender Design options and whether they were incorporated in the submitted Tender Design.

Tender Design Option WelTAG Significance/Adoption Summary

		Economy		Environment								Social						Transport Planning Objectives					Other Issues					
Ref	Option	Transport Economic Efficiency -TEE	Wider Economic Impacts - EALI	Noise	Local Air Quality	Greenhouse Gas Emissions	Landscape and Townscape	Bio-diversity	Heritage	Water Environment	Soils	Transport Safety	Personal security	Permeability	Physical Fitness	Social Inclusion	Equality, Diversity & Human Rights	TPO1 - Journey time / reliability Llanwnda to Plas Menai	TPO2 - Journey time / reliability Llanwnda to Caernarfon	TP03 - Reduce vehicles in communities	TPO4 - Casualty reduction targets	TPO5 - Improve network resilience / capacity	Health impact	Stakeholder acceptability	Technical and operational feasibility	Affordability and deliverability	Risk	Adopt
T01	Reduced 2+1 Standard	0	0	0	0	0	0	+	0	0	+	-	0	0	0	0	0	0	0	0	-	-	0	-	0	+	-	×
T02	Return to Agriculture	0	0	0	0	0	+	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	+	-	✓
T03	Plas Menai Rock Cut	0	0	+	0	0	-	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	- -	✓
T04	Bypass Horizontal Alignment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	+	+	+	✓
T05	Bypass Vertical Alignment	0	0	0	0	0	+ +	+	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	+ +	0	✓
T06	Structure Verges	0	0	0	0	-	0	0	0	0	0	+	0	0	0	0	0	0	0	0	+	+	0	-	0	- -	+	×
T07	Dinas Overbridge (S105)	0	0	-	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	✓
T08	Pont Cefnwerthyd Underbridge (S108)	WelTAG appraisal curtailed																										×
T09	Pont Ceriw Overbridge (S109)	0	0	-	0	0	-	+	0	0	+	+	+	0	0	0	0	0	0	0	+	0	0	+	0	0	0	✓
T10	Relocate Pont Bryn Mafon (S111)	0	0	0	0	0	-	-	0	0	-	-	0	0	0	0	0	0	0	0	-	0	0	-	0	-	-	✓
T11	Swale Drainage	0	0	0	0	+	+	+	0	+	0	0	0	0	0	0	0	0	0	0	0	+	0	+	0	0	0	✓

		Economy		Environment								Social						Transport Planning Objectives					Other Issues					
Ref	Option	Transport Economic Efficiency -TEE	Wider Economic Impacts - EALI	Noise	Local Air Quality	Greenhouse Gas Emissions	Landscape and Townscape	Bio-diversity	Heritage	Water Environment	Soils	Transport Safety	Personal security	Permeability	Physical Fitness	Social Inclusion	Equality, Diversity & Human Rights	TPO1 - Journey time / reliability Llanwnda to Plas Menai	TPO2 - Journey time / reliability Llanwnda to Caernarfon	TPO3 - Reduce vehicles in communities	TPO4 - Casualty reduction targets	TPO5 - Improve network resilience / capacity	Health impact	Stakeholder acceptability	Technical and operational feasibility	Affordability and deliverability	Risk	Adopt
T12	Over-Embankment Drainage	0	0	0	0	+	0	+	0	+	0	0	0	0	0	0	0	0	0	0	0	-	0	0	0	+	-	×
T13	Culvert Sizing	0	0	0	0	0	0	- -	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	- -	0	+	-	×
T14	Access to Park Area	WelTAG appraisal curtailed																										×
T15	FP19 Diversion	0	0	0	0	0	0	+	0	0	0	-	+	0	0	0	0	0	0	0	-	+	0	0	+	+	-	✓
T16	A4085 Diversion	0	0	-	0	0	-	-	0	0	0	+	0	0	0	0	0	0	0	0	0	+	0	0	-	-	+	×
T17	Bethel Road Strategy	+ +	0	0	0	+	+	-	+	0	-	-	0	-	0	0	0	0	0	0	-	+	0	-	+	+ + +	-	✓
T18	Crug Farm Link Alternative	0	0	0	0	-	-	-	0	0	-	+	0	0	0	0	0	0	0	0	+	0	0	0	0	-	-	×
T19	Crug Lane Re-connection	- - -	+	-	0	-	- -	-	-	0	-	- -	0	0	0	+	0	0	0	-	-	+	0	-	- -	- - -	- -	×
T20	Plas Menai Left Filter	WelTAG appraisal curtailed																										×

4.6 Departures from Standard

4.6.1.1 No formal assessment was made of departures from standard required within the Tender Design. However, subsequent reviews indicated that several departures, mostly inherent in the Conceptual Design, would be required.

No.	Departure from Standard	Initially identified at
1	Departure from TD 70/08 clause 3.9, for the location of a 2+1 conflicting crossover in the northern section on a curve of radius >=2880m.	Conceptual Design
2	Departure from TD 70/08 clause 3.11, for the location of a WS2+1 interface on a curve of radius >=720m on the southbound carriageway near Plas Menai Roundabout.	Conceptual Design
3	Departure from TD 27/05 clauses 4.2.1 and 4.7.2, for the reduced side road carriageway, hard strip, and verge widths.	Conceptual Design
4	Departure from TD 27/05 clause 4.11.13, for the reduced VRS set back at Ty'n Llan overbridge.	Conceptual Design
5	Departure from TD 27/05 clause 4.11.13, for the reduced VRS set back at Bethel Road B4366 overbridge.	Tender Design
6	Departure from TD 42/95 clauses 7.5 and 7.6, for the reduced visibility at Bethel Road (B4366) crossroads.	Tender Design

4.7 Risk

4.7.1.1 Although the Tender Design development was chiefly guided to optimise for particular design challenges, in so doing it has significantly reduced the overall scheme risk. The key scheme risk of confirmation of Orders at Public Local Inquiry still remains but is significantly reduced by consideration of stakeholder effects, but the appraisal process has identified several new and residual risks that may not have been considered previously:

- Importance of bat flightpaths and potential NRW objection;
- Poor topographical survey information and ability accurately identify constraints;
- Poor geotechnical data sources and ability to define earthworks balance;
- Flooding sensitivity, particularly Gwyrfai, and potential NRW objection;
- Departure from Standard approvals (within Conceptual Design);
- Managing Gwynedd Council expectations in particular off-line improvement works.

5 PRELIMINARY DESIGN

5.1 Option Identification

5.1.1.1 The identification of options during the Preliminary Design stage was a collaborative activity coordinated within Technical Working Groups (TWG) and discipline workshops attended by representatives of all project parties. These TWG and Workshops were informed by stakeholder consultations and new data sources and identified potential project issues.

5.1.1.2 The collection of additional data ran in parallel with the design development, which in turn identified scheme features that might be optimised. Many design options were discounted during initial appraisal and therefore are not documented in this report. However the options appraised below do cover the key design choices investigated during development of the Preliminary Design and the agreed recommendations.

5.1.1 Preliminary Design Option P01 - Plas Menai Cut

5.1.1.1 Description

The Tender Design earthworks profile for the Plas Menai cutting was based on extremely limited published geological information, the most recent BGS mapping being dated 1852, and no intrusive ground investigation. The Tender Design comprised 1:2 slopes through any, presumed shallow, superficial deposits and the weathered rock profile, with 1:1 cutting slopes through the slightly weathered/fresh rock. The design included both a rock trap ditch and a rock catch fence. Based upon the published information available and the rock outcrops visible in the area of the Plas Menai cutting it was assumed at Tender stage that the cut would be exclusively in rock with very shallow superficial deposits.

Intrusive ground investigation data has provided details of the geology and geological structure in the area of the cut that has resulted in a revision of the Tender Design to accommodate the ground conditions.

The ground investigation has identified a possible Horst/Graben structure with a potential cross cutting fault within the proposed northern side slope of the cutting. The impact of this structure appears to have been to allow the accumulation of deep superficial deposits in the southern portion of the cutting, up to 19.0m of glacial till having been encountered.

This has resulted in shallower slopes being proposed throughout the cutting at 1:2.5. This side slope has been arrived at following a slope stability assessment undertaken utilising draft GI data. While the stability analysis has been undertaken on the section of cutting in the glacial till, the same side slopes have been adopted throughout the entire cutting, including in the areas of rock, for the following reasons:

- 1:2.5 side slopes require less maintenance, are easier and, safer to inspect and maintain;
- Natural slopes in the area of the cut are generally low angle;
- Rock catch traps and rock catch fences are not required and therefore less future maintenance required;
- The adoption of steep side slopes through the rock areas may have resulted in a *"frost trap"* as it would be aligned north-south. This would have been made

worse by the fact that the slope of the cutting is downward to the north with a round-about at its base.

5.1.1.2 Appraisal

Economy	**Assessment / Comment**	**Significance**
Transport Economic Efficiency -TEE	More cut volume, additional surplus for works use, no rock catch	**0**
Wider Economic Impacts - EALI	No impact	**0**
Environment		
Noise	Wider cut, potentially more noise dispersal, limited receptors	**0**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	More excavation, construction plant movements	**-**
Landscape and Townscape	Increased landscaping potential, green slopes	**+ +**
Bio-diversity	Potential to improve habitat	**+**
Heritage	No impact	**0**
Water Environment	Potentially less turbidity in surface run-off	**+**
Soils	More landtake	**-**
Society		
Transport Safety	Reduced roaduser impact risk (rock catch / VRS / ditch)	**+**
Personal security	No impact	**0**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**
Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	Slight reduction, fewer obstacles	**0**
TPO5 - Network resilience / capacity	Reduced maintenance cost (rock cut)	**+**
Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	WG/NMWTRA for, landowners against (compensated)	**0**
Technical and operational feasibility	No impact	**0**
Affordability and deliverability	Increased cost / time	**-**
Risk	Reduced reliance on good quality rock	**+**

5.1.1.3 Key advantages:

- As a result of shallower slopes the geotechnical risk reduced;

- Reduced long-term maintenance as shallower slopes are more resilient and, both the rock catch trap and fence are removed;
- Safer and easier to inspect and maintain shallower slopes;
- Top-soiled and vegetated slopes will reduce turbidity of run-off compared to a steep rock slope;
- Rock fall margin not required and therefore, width of highway corridor reduced by around 2.0m on each side;
- Shallower and green slopes are more in keeping with the natural geomorphology/landscape of the area;
- Reduced visual impact over compared to a rock cutting;
- Risk of developing a frost trap greatly reduced.

5.1.1.4 Key disadvantages:

- An increase in excavation volumes and therefore excavation costs as a result of the greater cut (this needs to be balanced by the overall benefit to the Scheme of having this material for use as fill for embankments);
- A potential for an earthworks material surplus, which would require management; but which would be managed/influenced through the ongoing design process to ensure it is optimised;
- As a result of the shallower side slopes the cutting becomes wider and therefore an increased land-take is required;
- With the shallower side slopes traffic noise propagation may increase.

5.1.1.5 Recommendation

Incorporate in the Preliminary Design.

5.1.2 Preliminary Design Option P02 - Removal of Return to Agriculture

5.1.2.1 The decision at Tender Design to return land to agriculture by adopting 1:10 side slopes has been reviewed.

Following identification of any surplus material, suitable locations would need to be identified. Discussions would also need to be held with the affected landowners to determine whether they would be agreeable to the proposal. Although in the long term less land take would be required, the 1:10 side slopes would affect a greater area during construction and the associated loss of habitats.

5.1.2.2 Appraisal

Economy	**Assessment / Comment**	**Significance**
Transport Economic Efficiency -TEE	Disposal of unsuitable material	**-**
Wider Economic Impacts - EALI	No impact	**0**

Environment		
Noise	No impact	**0**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	Movement of unsuitable	**0**
Landscape and Townscape	More visual intrusion, landform / hedgerows retained	**-**
Bio-diversity	Hedgerow / habitats retained	**+**

Heritage	No change	**0**
Water Environment	No change	**0**
Soils	Reduced landtake, no farmland drainage improvement	**0**

Society		
Transport Safety	No impact	**0**
Personal security	No impact	**0**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	No change	**0**
TPO5 - Network resilience / capacity	No change	**0**

Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	Reduced negotiation landowner / SEBs	**0**
Technical and operational feasibility	Standard site activity	**0**
Affordability and deliverability	No impact	**0**
Risk	Reduced approvals	**0**

5.1.2.3 Key advantages:

- Reduced dependency on landowner agreement;
- Existing landforms preserved;
- Hedgerow & ditch habitats retained.

5.1.2.4 Key disadvantages:

- Slightly wider highway corridor;
- Embankment maintenance liability;
- No farmland (soils/drainage) improvement;
- New unsuitable fill disposal sites required.

5.1.2.5 Recommendation

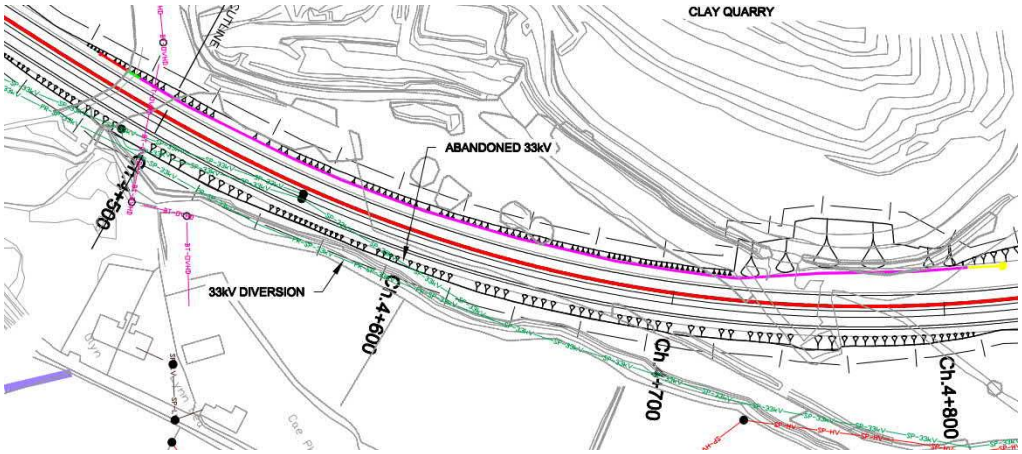
Due to the procedural complexities, the slacker side slopes for return to agriculture are not being progressed.

Removal of return to agriculture incorporated in the Preliminary Design.

5.1.3 Preliminary Design Option P03 - Landslip/Quarry Clearance

5.1.3.1 Description

A review of the historical records, new topographical survey and preliminary site investigation observations indicated two potentially critical geotechnical constraints to the west of the bypass in the vicinity of the quarry; an on-going landslip at Ch.4+300 and a clay quarry edge Ch.4+770.



A revised alignment was investigated to avoid both of these geotechnical constraints by shifting the horizontal alignment east by approximately 15m and raising the vertical alignment by approximately 1m.

Further site investigation testing indicated that the landslip may not be progressive and that the back scar was approximately 20m from the toe of the earthworks, significantly reducing risk to bypass. The clay quarry edge was also found to be stable, allowing for the earthworks to spill onto a quarry upper bench.

5.1.3.2 Recommendation

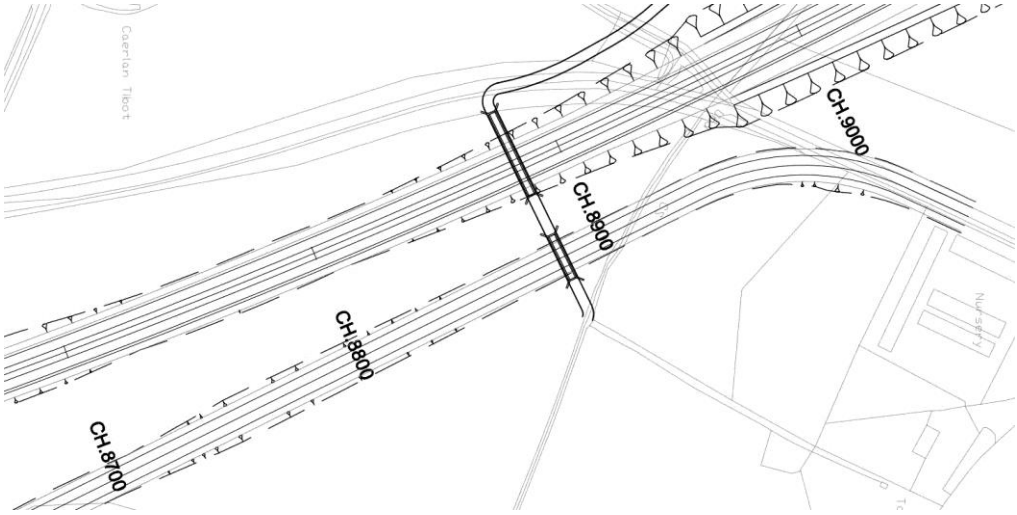
The WelTAG appraisal was curtailed on receipt of the further site investigation data, showing geotechnical features not as critical as predicted.

Not incorporated in the Preliminary Design.

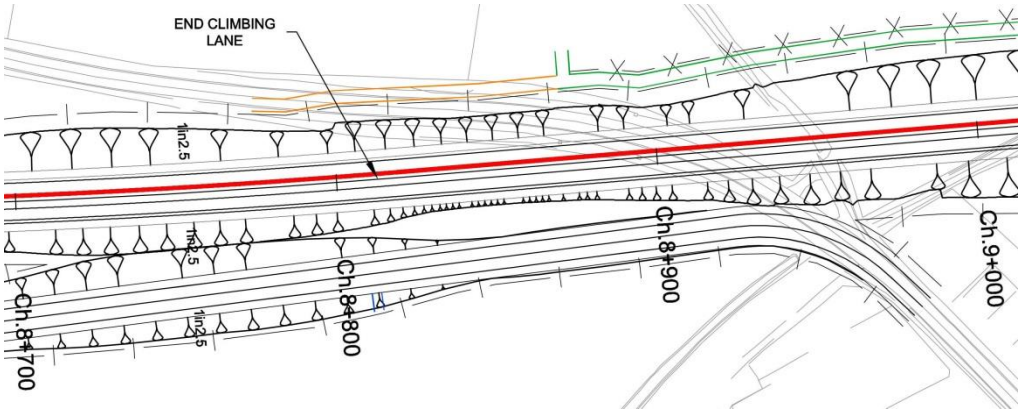
5.1.4 Preliminary Design Option P04 - Crug Farm Landtake

5.1.4.1 Description

During initial consultation with the Crug Farm stakeholders on the Tender Design proposals, they raised potential objections to the partial loss of the plant nursery field at Ch.8+950 due to the proposed new side road link (see below).



As a result, the mainline horizontal alignment was moved approximately 19m west and the realigned Crug Lane side road moved closer to the bypass by approximately 13m to minimise the landtake on Crug Farm nursery (see below). The proposed alignment Longitudinal Section (3513874-PB-06-ZZ-DR-J-00001) is also provided in Appendix C.



5.1.4.2 Appraisal

Economy	Assessment / Comment	Significance
Transport Economic Efficiency -TEE	No impact	**0**
Wider Economic Impacts - EALI	No impact	**0**

Environment		
Noise	No impact	**0**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	No impact	**0**
Landscape and Townscape	Minimal change, narrower highway corridor	**0**
Bio-diversity	No impact	**0**
Heritage	Minimal change, slightly closer to SAM	**0**
Water Environment	No impact	**0**
Soils	Minimal change	**0**

Society		
Transport Safety	No impact	**0**
Personal security	No impact	**0**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	No change	**0**
TPO5 - Network resilience / capacity	No change	**0**

Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	Crug Farm for	**+**
Technical and operational feasibility	No impact	**0**
Affordability and deliverability	No impact	**0**
Risk	Reduced risk PLI objection	**+**

5.1.4.3 Key advantages:

- Reduce landtake from of Crug Farm nursery field from 50% of field to 5%;
- Closer bypass / side road, reduced landtake, severed land;
- Reduces risk of Crug Farm objection at Public Local Inquiry.

5.1.4.4 Key disadvantages:

- Longer / deeper westside ditch relocation;
- Closer to Scheduled Ancient Monument, does not breach field boundary.

5.1.4.5 Recommendation

Incorporate in the Preliminary Design.

5.1.5 Preliminary Design Option P05 - Removal K=55 crests

5.1.5.1 Description

The Conceptual Design included a number of K=55 crests. As part of the Tender Design, the alignment was reviewed and the number increased.

TD 9/93 prevents combined horizontal and vertical alignment relaxations, but horizontal alignment and visibility relaxation combinations are permitted. As a result of the Tender Design proposals, there was an increased potential for departures from standard and the introduction of wider verges than necessary, to 'see round the bend'.

Consideration was therefore given to re-engineering the vertical alignment to remove all of the K=55 crests in the Conceptual Design and the Tender Design, and replace with full K=100 crests. This would require no departures but would increase landtake on the shoulders of the crest curve, but reduce landtake due to the reduced verge widths.

The proposed alignment Longitudinal Section (3513874-PB-06-ZZ-DR-J-00001) is provided in Appendix C.

5.1.5.2 Appraisal

Economy	**Assessment / Comment**	**Significance**
Transport Economic Efficiency -TEE	More fill requirement	**-**
Wider Economic Impacts - EALI	No impact	**0**

Environment		
Noise	Slight increase noise shadow	**0**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	No impact	**0**
Landscape and Townscape	Slight increase visual intrusion	**0**
Bio-diversity	No impact	**0**
Heritage	No impact	**0**
Water Environment	No impact	**0**
Soils	No impact	**0**

Society		
Transport Safety	Improved, full standard, visibility	**+**
Personal security	No impact	**0**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	Marginal visibility improvement savings	**0**
TPO5 - Network resilience / capacity	No change	**0**

Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	WG/NMWTRA for	**+**
Technical and operational feasibility	No impact	**0**
Affordability and deliverability	No impact	**0**
Risk	No departure approvals required	**+**

5.1.5.3 Key advantages:

- Avoids vertical alignment departure;
- Reduced verge / structure widths, landtake / cost saving.

5.1.5.4 Key disadvantages:

- Increased fill requirement returning to GL from underbridge / culvert 'hard spot'.

5.1.5.5 Recommendation

Incorporate in the Preliminary Design.

5.1.6 Preliminary Design Option P06 - Side Road Section

5.1.6.1 Description

As required by the Works Information Cl 4.22.5, consultation was undertaken with Gwynedd Council regarding the design standards of various side roads.

Gwynedd Council revealed that they would prefer to maintain the existing side road width up to and through structures, both over and under the bypass. They believed that excessive widening of side road section on approach to or at structures could be an increased hazard, and that a consistent carriageway section would be preferable.

The Tender Design was therefore reviewed, and the following sections are proposed. In terms of the side road, LHS equates to the southern verge.

					Side Road (pre-structure)					Side Road (Structure)				
Structure					LHS		c/way	RHS		LHS		c/way	RHS	
BBJV Ref.	Chainage	WG Asset No.	WG Name	Type	verge	h/s		h/s	verge	verge	h/s		h/s	verge
S101	0+180	A487 550 C68	Ty Hên Culvert	1.8m Pipe			n/a					FDitch		
S101A	0+420	A487 561	Pont Parc Underpass	Box Underbridge	1.0	0.0	3.8	0.0	1.0	1.2	0.0	3.7	0.0	2.3
S102	0+500	A487 565	Afon Rhyd Culvert	Box Culvert			n/a					RRhyd		

Structure					Side Road (pre-structure)					Side Road (Structure)				
					LHS		c/way	RHS		LHS		c/way	RHS	
BBJV Ref.	Chainage	WG Asset No.	WG Name	Type	verge	h/s		h/s	verge	verge	h/s		h/s	verge
S103	0+850	A487 571	Ty'n Llan Overbridge	Overbridge	2.0	0.0	5.5	0.0	2.0	1.4	0.0	5.5	0.0	0.6
S104	1+400	A487 571 C80	Geufron Culvert	1.8m Pipe			n/a					Tributary		
S105	1+550	A487 575	Dinas Accommodation Underpass	Box Underbridge	0.5	0.0	4.0 PMA	0.0	0.5	0.5	0.0	3.5 PMA	0.0	0.5
S106	1+900	A487 581	Afon Gwyrfai Viaduct	Viaduct			n/a					n/a		
S107	2+290	A487 585	Pont Llydiart Gwyn	Box Underbridge	2.0	0.0	3.7	0.0	2.0	2.3	0.0	3.7	0.0	1.2
S108	2+700	A487 591	Pont Cefnwerthyd	Underbridge	7.0 PMA	4.8 CycleR	11.8 WHR			0.5	2.7 CycleR	4.0 WHR	4.2 PMA	0.5
S109	2+910	A487 601	Pont Ceriw NMU Overbridge	Overbridge	2.5	0.0	3.7	0.0	2.5	0.5	0.0	3.0 F/W	0.0	0.5
S109A	2+930 (SR)	A487 601 C01	Pen Y Bryn Culvert 3	1.8m Pipe	2.5	0.0	3.7	0.0	2.5	2.5	0.0	3.7	0.0	2.5
S109B	3+150	N/A	Pen Y Bryn Culvert 4	0.6m Pipe			n/a					n/a		
S110A	3+560 (SR)	A487601 C58	Pen Y Bryn Culvert 2	1.8m Pipe	2.5	0.0	7.3	0.0	2.5	2.5	0.0	8.8	0.0	9.5 VISI
S110	3+682	A487 601 C73	Pen y Bryn Culvert 1	1.8m Pipe			n/a					n/a		
S111	3+930	A487 611	Pont Bryn Mafon	Box Underbridge	2.5	0.0	3.7	0.0	2.5	1.2	0.0	3.7	0.0	2.3 VISI
S111A	4+040	A487 611 C08	Bryn Mafon Culvert 1	1.8m Pipe	1.5	0.0	3.0	0.0	1.5			n/a		
S111B	4+070 (SR)	A487 611 C09	Bryn Mafon Culvert 2	1.5m Pipe	1.5	0.0	3.0	0.0	1.5	2.5	0.0	3.7	0.0	2.5
S112	5+450	A487 621	Pont Afon Seiont Newydd	Viaduct	2.0 F/W	1.0 Wall	6.5 A4085	0.0	1.0 Wall	2.0 F/W	0.0	6.5 A4085	0.0	1.2
S112A	6+500(SR)	A487 621 C61	Bodrual Culvert 2	1.5m Pipe	2.0	0.0	7.3	0.0	2.0	2.5	0.0	7.3	0.0	3.5
S112B	6+460	A487 621 C59	Bodrual Culvert 1	1.5m Pipe			n/a					n/a		
S112C	5+850	N/A	Cibyn Culvert 1	0.6m Pipe			FDitch					FDitch		
S112D	5+970	N/A	Cibyn Culvert 2	0.6m Pipe			FDitch					n/a		
S113A	7+160	A487 625	FP 36	Box Underbridge		2.0 FP36	FDitch				2.3 FP36	0.7 FDitch		
S114	8+160	A487 631	Afon Cadnant Cattle Creep / Culvert	Box Underbridge	0.5	4.0 PMA	0.5 Verge	2.0 Cadnant			2.7 CCreep	0.7 Cadnant		
S114A	8+180(SR)	A487 631 C08	Lon Glai Culvert	1.8m Pipe	1.5	0.0	5.5	0.0	1.5	2.5	0.0	5.5	0.0	2.5
S115	8+400	A487 635	Bethel Road Overbridge	Overbridge	2.5	0.0	7.3 B4366	0.0	2.5	0.6	0.0	7.3 B4366	0.0	1.4 VISI
S115A	8+400(SR)	A487 635 C01	Bethel Road Culvert 1	1.8m Pipe	2.5	0.0	7.3 B4366	0.0	2.5	3.5 VISI	0.0	7.3 B4366	0.0	5.0 VISI
S115B	8+490(SR)	A487 635 C03	Bethel Road Culvert 2	1.8m Pipe	2.5	0.0	5.5	0.0	2.5	2.5	0.0	5.5	0.0	2.5

5.1.6.2 Appraisal

Economy	**Assessment / Comment**	**Significance**
Transport Economic Efficiency -TEE	Cost saving, reduced width roads & structures	**+**
Wider Economic Impacts - EALI	No impact	**0**
Environment		
Noise	No impact	**0**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	Reduced construction materials	**0**
Landscape and Townscape	Slight improvement, reduced intrusion	**+**
Bio-diversity	No impact, reduced spans impact on wildlife / bat connectivity	**0**
Heritage	No impact	**0**
Water Environment	No impact	**0**
Soils	Reduced landtake	**0**
Society		
Transport Safety	Consistent carriageway width, reduced verge margin	**+**
Personal security	No impact	**0**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**
Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	Marginal improvement	**0**
TPO5 - Network resilience / capacity	Narrower carriageway, increased maintenance TM	**0**
Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	Gwynedd Council / WG for	**+**
Technical and operational feasibility	No impact	**0**
Affordability and deliverability	Reduced costs	**+**
Risk	Risk highway authority refusal to accept	**0**

5.1.6.3 Key advantages:

- Pavement / structure cost saving;
- Reduced side road footprint;
- Consistent / safer driver experience;
- Gwynedd Council preference.

5.1.6.4 Key disadvantages:

- Reduced scope future upgrade;
- Potential safety hazard narrow verges;
- Highway Authority approval required.

5.1.6.5 Recommendation

Incorporate in the Preliminary Design.

5.1.7 Preliminary Design Option P07 - Reduced Road Lighting

5.1.7.1 Description

Newtown Bypass included a departure to reduce lighting at roundabouts to the circulatory carriageway only (i.e. provide a 'ring of light'). Following the precedence set by Newtown Bypass, the preliminary design considered the provision of a 'ring of light' and the removal of the existing lighting provision on the abandoned B4366 Bethel Road Roundabout.

Gwynedd Council has raised concern over the proposed 'ring of light' departure, and as a consequence the roundabout lighting proposal was revised to full standard lighting at Goat and Plas Menai Roundabouts and 'no lighting' at Meifod and Cibyn Roundabouts. The removal of roundabout lighting at Meifod and Cibyn Roundabouts would be a departure from standard.

5.1.7.2 Appraisal

Economy	**Assessment / Comment**	**Significance**
Transport Economic Efficiency -TEE	Slight capital / maintenance cost reduction	**0**
Wider Economic Impacts - EALI	No impact	**0**

Environment		
Noise	No impact	**0**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	Slight reduction energy use	**0**
Landscape and Townscape	Reduced light pollution	**+**
Bio-diversity	Improved connectivity bat flightpaths at 'dark' junctions, no change at existing 'lit' junctions	**+**
Heritage	No impact	**0**
Water Environment	No impact	**0**
Soils	No impact	**0**

Society		
Transport Safety	Reduced nighttime NMU visibility at Meifod and Cibyn Roundabouts	**-**
Personal security	Reduced personal security for NMUs at Meifod and Cibyn Roundabouts	**-**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	Overall more NMU users subject to reduced visibility during dark conditions across the two 'dark' roundabouts	**-**
TPO5 - Network resilience / capacity	No change	**0**

Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	Gwynedd Council/Ramblers/Sustrans against, WG/NRW for,	**-**
Technical and operational feasibility	No impact	**0**
Affordability and deliverability	No impact	**0**
Risk	Lighting departure required	**-**

5.1.7.3 Key advantages:

- Reduced street lighting capital and maintenance costs;
- Reduced lighting beneficial to bat flightpaths, visual intrusion.

5.1.7.4 Key disadvantages:

- Bat issues & NRW objection at Goat and Plas Menai Roundabouts;
- Potential refusal of Gwynedd Council / NMWTRA to approve;
- Mix of lit and un-lit roundabouts on scheme, potential safety issues.

5.1.7.5 Recommendation

Incorporate in the Preliminary Design, although following the Lighting Technical Working Group held on 11th June 2015, this option may need to be revised to provide full standard lighting at Meifod Roundabout, and a 'ring of light' at Cibyn Roundabout.

5.1.8 Preliminary Design Option P08 - Removal of Underpass Lighting

5.1.8.1 Description

Volume 2 of the Works Information (Clause 4.22.28) states that "The Contractor shall provide vandal proof underpass lighting."

This design option considers the proposal to not light underpasses:

- S101A (Pont Parc Underpass);
- S107 (Pont Llydiart Gwyn);
- S111 (Pont Bryn Mafon);
- the A4085 span of S112 (Seiont Viaduct); and
- S113A (FP36).

S105 (Dinas Farm Underpass) and S114 (Afon Cadnant Cattle Creep) are both private means of access and would always have been unlit.

The provision of lighting in this rural and currently unlit location, would have a detrimental impact on bat flightpaths.

5.1.8.2 Appraisal

Economy	**Assessment / Comment**	**Significance**
Transport Economic Efficiency -TEE	Minimal cost/maintenance	**0**
Wider Economic Impacts - EALI	No impact	**0**

Environment		
Noise	No impact	**0**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	No impact	**0**
Landscape and Townscape	Potential light pollution	**0**
Bio-diversity	Dark underpass better for bat flightpath connectivity	**+**
Heritage	No impact	**0**
Water Environment	No impact	**0**
Soils	No impact	**0**

Society		
Transport Safety	No impact	**0**
Personal security	Reduced personal security for NMUs in dark underpass	**-**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	'Dark' underpass likely to discourage vulnerable/ elderly users to make trips associated with key services and personal needs	**-**
Equality, Diversity & Human Rights	No impact	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	No change	**0**
TPO5 - Network resilience / capacity	No change	**0**

Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	Gwynedd accept provided no requirement, WG/NRW for	**+**
Technical and operational feasibility	No impact	**0**
Affordability and deliverability	No impact	**0**
Risk	Increased personal safety risk / reduced vandalism risk	**0**

5.1.8.3 Key advantages:

- Improved mammal / bat flightpath connectivity;
- Reduced cost/maintenance liability;
- Acceptable to Gwynedd Council.

5.1.8.4 Key disadvantages:

- Discourages non-daylight use;
- Personal safety concerns;
- Departure required.

5.1.8.5 Recommendation

Incorporate in the Preliminary Design.

5.2 Structures

5.2.1 Coverage

5.2.1.1 Details of the Preliminary Design structure strategy is provided in the Structure Design Options Report (3513874-PB-XX-XX-RP-S-00001) and a Structure Location Plan (3513874-PB-XX-XX-DR-S-00001) is provided in Appendix C. However this Highways Design Options Report addresses the structure type, dimensions and location options derived from the highway-driven constraints.

5.2.1.2 Structures as defined by BD 2/12 are listed in the following table, and considered further in the Structures Design Options Report. Design options that proposed modifications to the structure type, dimensions and location options of these structures are considered in this Section 5.5.

5.2.1.3 The structures highlighted blue also provide a hydraulic capacity and any proposed design options for those are considered in Section 5.6 Drainage, in addition to any 0.6m diameter pipes.

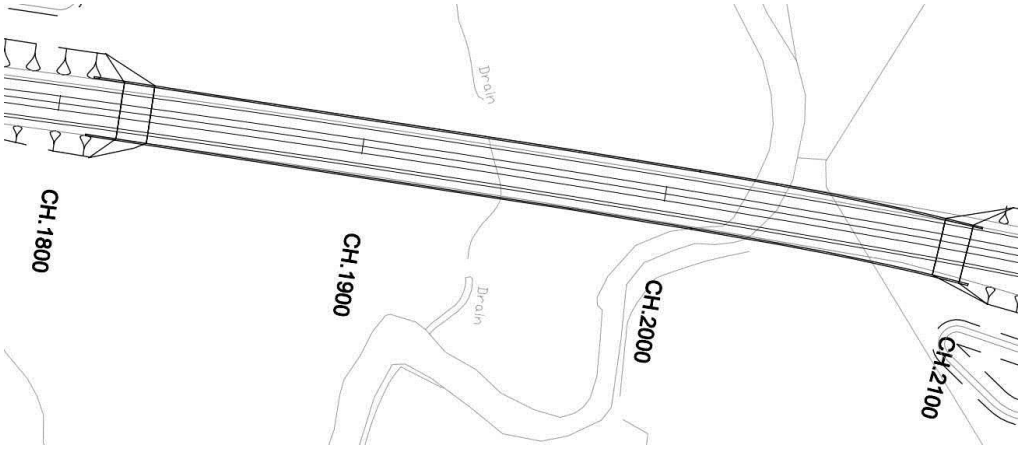
BBJV Ref.	Chainage	WG Asset No.	WG Name	Type
S101	0+180	A487 550 C68	Ty Hên Culvert	1.8m Pipe
S101A	0+420	A487 561	Pont Parc Underpass	Box Underbridge
S102	0+500	A487 565	Afon Rhyd Culvert	Box Culvert
S103	0+850	A487 571	Ty'n Llan Overbridge	Overbridge
S104	1+400	A487 571 C80	Geufron Culvert	1.8m Pipe
S105	1+550	A487 575	Dinas Accommodation Underpass	Box Underbridge
S106	1+900	A487 581	Afon Gwyrfai Viaduct	Viaduct

BBJV Ref.	Chainage	WG Asset No.	WG Name	Type
S107	2+290	A487 585	Pont Llydiart Gwyn	Box Underbridge
S108	2+700	A487 591	Pont Cefnwerthyd	Underbridge
S109	2+910	A487 601	Pont Ceriw NMU Overbridge	Overbridge
S109A	2+930 (SR)	A487 601 C01	Pen Y Bryn Culvert 3	1.8m Pipe
S110A	3+560 (SR)	A487601 C58	Pen Y Bryn Culvert 2	1.8m Pipe
S110	3+682	A487 601 C73	Pen y Bryn Culvert 1	1.8m Pipe
S111	3+930	A487 611	Pont Bryn Mafon	Box Underbridge
S111A	4+040	A487 611 C08	Bryn Mafon Culvert 1	1.8m Pipe Bat Culvert
S111B	4+070 (SR)	A487 611 C09	Bryn Mafon Culvert 2	1.5m Pipe
S112	5+450	A487 621	Pont Afon Seiont Newydd	Viaduct
S112A	6+500(SR)	A487 621 C61	Bodrual Culvert 2	1.5m Pipe
S112B	6+460	A487 621 C59	Bodrual Culvert 1	1.5m Pipe
S113A	7+160	A487 625	FP 36	Box Underbridge
S114	8+160	A487 631	Afon Cadnant Cattle Creep / Culvert	Box Underbridge
S114A	8+180(SR)	A487 631 C08	Lon Glai Culvert	1.8m Pipe
S115	8+400	A487 635	Bethel Road Overbridge	Overbridge
S115A	8+400(SR)	A487 635 C01	Bethel Road Culvert 1	1.8m Pipe
S115B	8+490(SR)	A487 635 C03	Bethel Road Culvert 2	1.8m Pipe

5.2.2 Preliminary Design Option P09 - Gwyrfai Viaduct Position (S106)

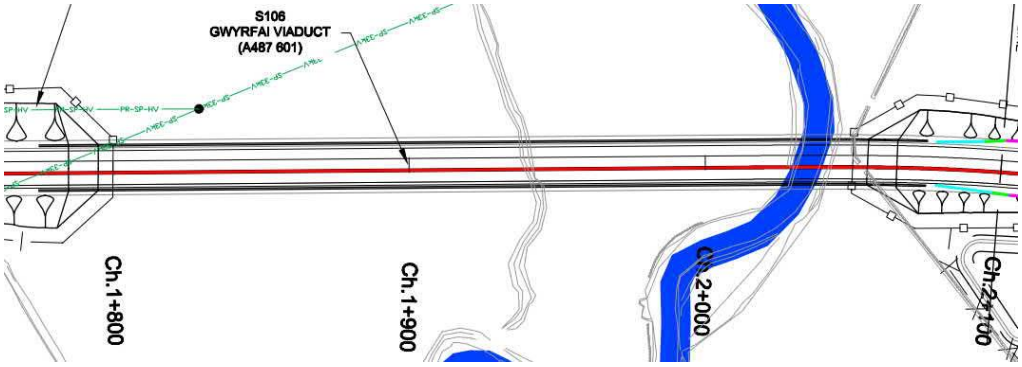
5.2.2.1 Description

The baseline flood modelling indicates that the extent of the Gwyrfai floodplain differs from that shown on the Natural Resources Wales flood mapping. In addition, the latest topographical and hydrographical surveys indicate the bed of the Gwyrfai is not as shown on the Ordnance Survey maps or topographical survey provided at tender (see below).



This design option considers an amendment to the horizontal alignment and the relocation of the northern abutment of the Gwyrfai Viaduct approximately 10m west to

avoid the meander of the river. The northern main river span is therefore reduced in length and the viaduct is straightened.



5.2.2.2 Appraisal

Economy	Assessment / Comment	Significance
Transport Economic Efficiency -TEE	Reduced cost, span/scour protection	+
Wider Economic Impacts - EALI	No impact	0

Environment		
Noise	No impact	0
Local Air Quality	No impact	0
Greenhouse Gas Emissions	No impact	0
Landscape and Townscape	No impact	0
Bio-diversity	Moves away from SAC, reduced impact	+
Heritage	No impact	0
Water Environment	No impact	0
Soils	No impact	0

Society		
Transport Safety	No impact	0
Personal security	No impact	0
Permeability	No impact	0
Physical Fitness	No impact	0
Social Inclusion	No impact	0
Equality, Diversity & Human Rights	No impact	0

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	0
TPO2 - Llanwnda to Caernarfon JT	No change	0
TPO3 - Traffic resident communities	No change	0
TPO4 - Casualty reduction target	No change	0
TPO5 - Network resilience / capacity	Reduced scour risk to structure	+

Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	WG/NMWTRA/NRW for	**+**
Technical and operational feasibility	Straight viaduct, reduced complexity	**+**
Affordability and deliverability	Shorter main river span	**0**
Risk	Reduced scour risk, risk on SAC	**+ +**

5.2.2.3 Key advantages:

- Reflects actual floodplain margins;
- Reduced river crossing skew and hence river main span;
- Viaduct straight in plan & elevation, simplified structure;
- Reduced risk of pier scour;
- SAC riverbank clearance enhanced;
- Boundaries more consistent with existing field boundaries.

5.2.2.4 Key disadvantages:

- Horizontal transition strays approximately 60m onto viaduct, but is considered acceptable;
- Llydiart Gwyn box underpass shifts approximately 6m west, but no change length.

5.2.2.5 Recommendation

Incorporate in the Preliminary Design.

5.2.3 Preliminary Design Option P10 - Gwyrfai Viaduct Span (S106)

5.2.3.1 Description

A value engineering opportunity has been recognised to potentially reduce the mandated length of Gwyrfai Viaduct.

Flood modelling work has been undertaken to evaluate the effects on both the flood plain and flood levels of replacing part of the southern section of the conforming eight-span steel composite viaduct with an impermeable embankment.

For the purposes of evaluation, flood modelling work has assumed the removal of an incremental number of spans from the southern end of the viaduct – models have been developed to test removal of 2, 3 or 4 complete viaduct spans and replacement with embankment.

From the flood modelling results, it would appear feasible to replace the 3 no. southern spans of the viaduct with an embankment, thereby giving rise to a 5 span steel composite viaduct. Additional flood culverts may be required to pass through the embankment placed into the floodplain, along with other mitigation measures.

5.2.3.2 Appraisal

Economy	**Assessment / Comment**	**Significance**
Transport Economic Efficiency -TEE	Reduced structure costs, increased fill	**+**
Wider Economic Impacts - EALI	No impact	**0**
Environment		
Noise	Potential beneficial, less propagation on embankment	**+**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	Fewer concrete materials, more fill transport	**0**
Landscape and Townscape	Slight beneficial, embankment mitigation	**+**
Bio-diversity	No impact	**0**
Heritage	No impact	**0**
Water Environment	Potential increased flooding mitigation works in floodplain	**-**
Soils	Landtake embankment & flood mitigation	**-**
Society		
Transport Safety	No impact	**0**
Personal security	No impact	**0**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**
Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	No change	**0**
TPO5 - Network resilience / capacity	Reduced structure maintenance	**+**
Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	NRW against, landowner possibly against, WG/TAA for	**-**
Technical and operational feasibility	Less challenging, craneage, piers	**+**
Affordability and deliverability	Reduced cost	**+**
Risk	NRW approval, insufficient fill	**- -**

5.2.3.3 Key advantages:

- Structure Capital Cost;
- Structure whole life costs;
- Earthwork balance;
- Additional screening & new bat flightpath.

5.2.3.4 Key disadvantages:

- Increase flood level;
- NRW objection (on encroachment not flood level impact).

5.2.3.5 Recommendation

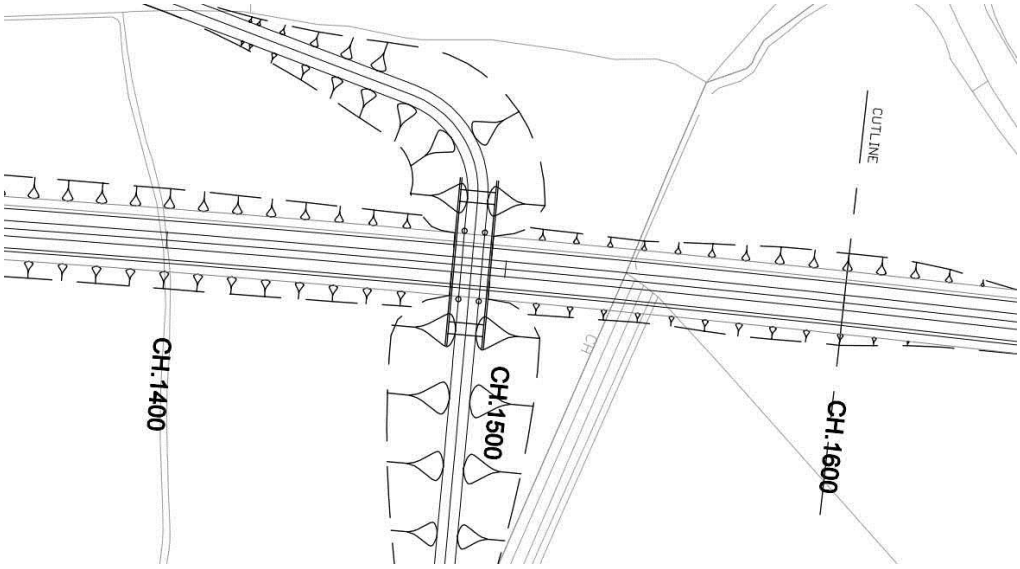
This value engineering proposal still requires substantiation through further design and stakeholder consultation, and if still considered feasible, may be developed through the remainder of Key Stage 3 as the preferred option.

At present, this option is not incorporated in the Preliminary Design.

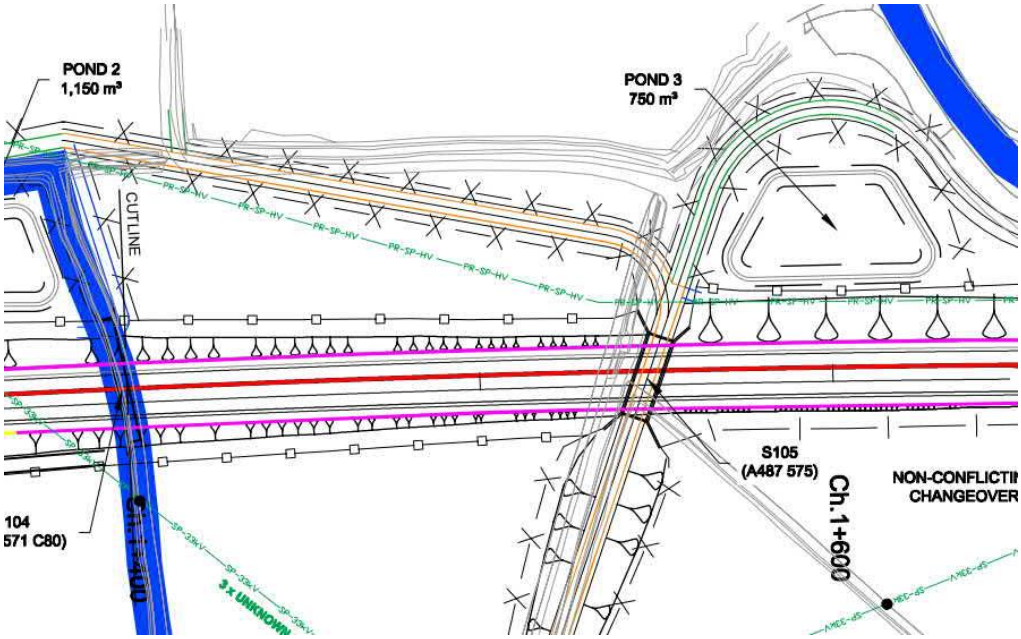
5.2.4 Preliminary Design Option P11 - Restore Dinas Underbridge (S105)

5.2.4.1 Description

As a result of new topographical survey data in the vicinity of S105 Dinas Farm Accommodation Bridge and the landowner's preference for an underbridge, this design option considers returning the proposed Tender Design overbridge (see below) to an underbridge.



New topographical survey data obtained since tender has identified a potentially new location for the Dinas Farm Accommodation Underpass approximately 80m further north than the Conceptual Design Dinas Underbridge. This new location preserves the vertical alignment of the bypass. The new underpass proposal ramps down from existing farm track to the east, passes under the bypass to an area of ground reduction to the west, incorporating relocated attenuation pond (see below). The bifurcated farm track can then serve three landowners. The farm track is graded such that there is a constant fall towards the Afon Gwyrfai outfall for drainage purposes.



5.2.4.2 Appraisal

Economy	Assessment / Comment	Significance
Transport Economic Efficiency -TEE	No impact	0
Wider Economic Impacts - EALI	No impact	0

Environment		
Noise	Slight reduction farm traffic noise	+
Local Air Quality	No impact	0
Greenhouse Gas Emissions	No impact	0
Landscape and Townscape	Slight reduction visual intrusion	+
Bio-diversity	No impact	0
Heritage	No impact	0
Water Environment	No impact	0
Soils	No impact	0

Society		
Transport Safety	No impact	0
Personal security	No impact	0
Permeability	No impact	0
Physical Fitness	No impact	0
Social Inclusion	No impact	0
Equality, Diversity & Human Rights	No impact	0

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	No change	**0**
TPO5 - Network resilience / capacity	No change	**0**

Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	Landowner preference for underbridge	**+**
Technical and operational feasibility	No impact	**0**
Affordability and deliverability	No impact	**0**
Risk	Reduced potential for PLI objection	**+**

5.2.4.3 Key advantages:

- Landowner preference;
- Reduced structure costs;
- Improved bat performance.

5.2.4.4 Key disadvantages:

- Additional attenuation pond with outfall to Gwyrfai SAC;
- Significant ground reduction.

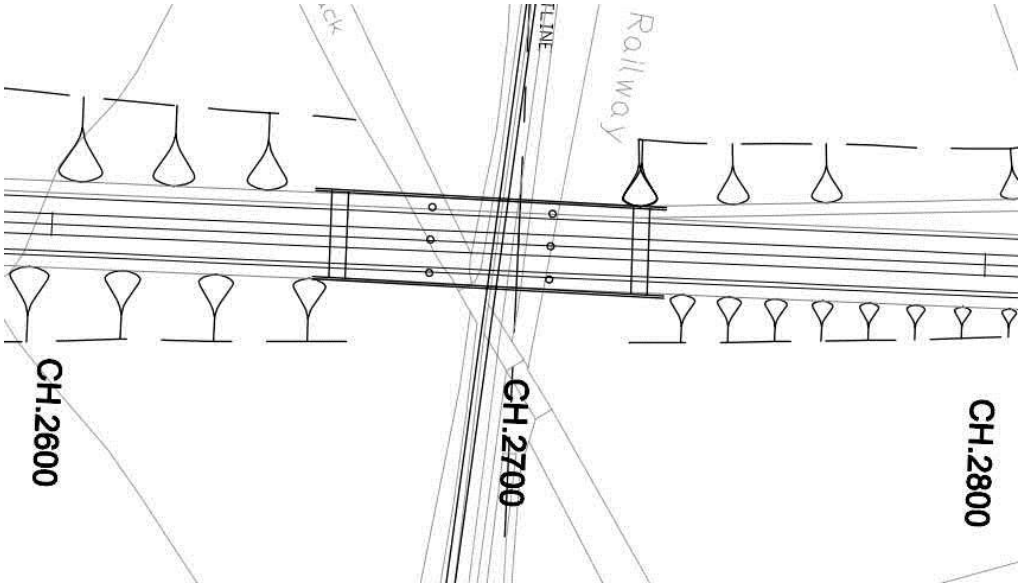
5.2.4.5 Recommendation

Incorporate in the Preliminary Design.

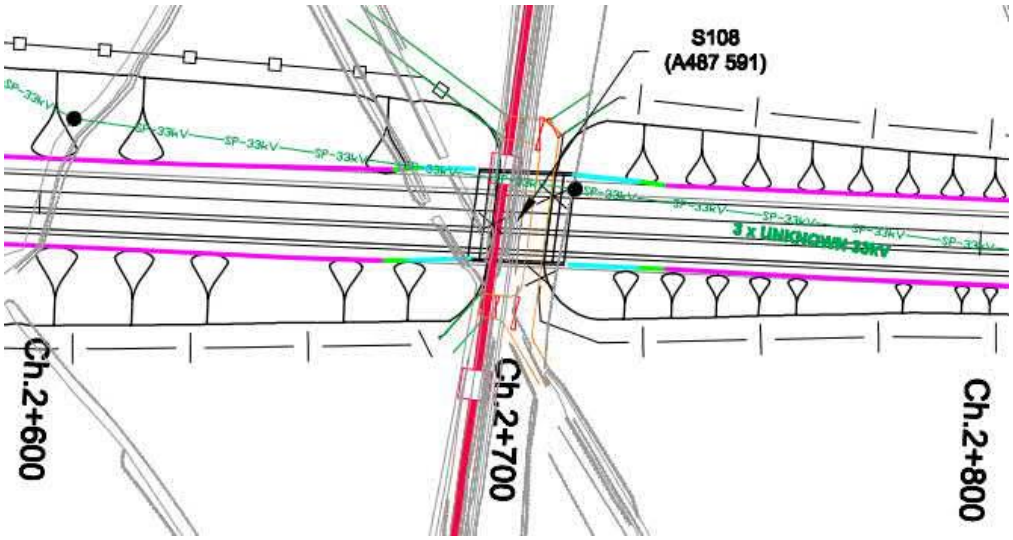
5.2.5 Preliminary Design Option P12 - Pont Cefnwerthyd Span (S108)

5.2.5.1 Description

The tender design included two private means of access on either side of the Welsh Highland Railway to provide access to all four quadrants of land surrounding structure S108. These were joined by a retained existing farm track level crossing. Therefore the bypass underbridge was required to span 2no. private means of access, a cycle route and the Welsh Highland Railway boundary (see below).



Multiple options were investigated to reduce the underbridge span. The preferred option is to provide two new Welsh Highland Railway level crossing points to the east and the west. These would be linked by a single private means of access on the northern side of the railway, whilst the cycle route is retained on the southern side. The necessary rail gauge clearances would be preserved, but the Welsh Highland Railway corridor reduced so that the private means of access is located within the existing Welsh Highland Railway boundaries (see below).



5.2.5.2 Appraisal

Economy	Assessment / Comment	Significance
Transport Economic Efficiency -TEE	Reduced structure capital / maintenance costs	+
Wider Economic Impacts - EALI	No impact	0

Environment		
Noise	Slight noise reduction, extended embankment	**0**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	Reduced concrete / steel construction materials	**+**
Landscape and Townscape	Slight reduction visual impact	**0**
Bio-diversity	Slight reduction mammal / bat connectivity under bypass	**-**
Heritage	No impact	**0**
Water Environment	No impact	**0**
Soils	Slight increase landtake	**0**

Society		
Transport Safety	2nd railway crossing closer to WHR bend, visi safety	**-**
Personal security	No impact	**0**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	Marginal railway safety issue	**0**
TPO5 - Network resilience / capacity	Reduced structure maintenance, engineered slope	**0**

Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	Landowner preference 2xPMA, WHR landtake, WG/ TAA/ Sustrans support	**-**
Technical and operational feasibility	Safety reduced railway working, craneage reduced	**+**
Affordability and deliverability	Significant structure cost saving	**+ +**
Risk	WHR approval for 2nd railway crossing & landtake	**-**

5.2.5.3 Key advantages:

- Reduced structure costs;
- Improved construction safety.

5.2.5.4 Key disadvantages:

- Landowner preference for 2no. Private Means of Access;
- Slight reduction mammal/bat connectivity;
- Atypical abutment form, reinforced soil.

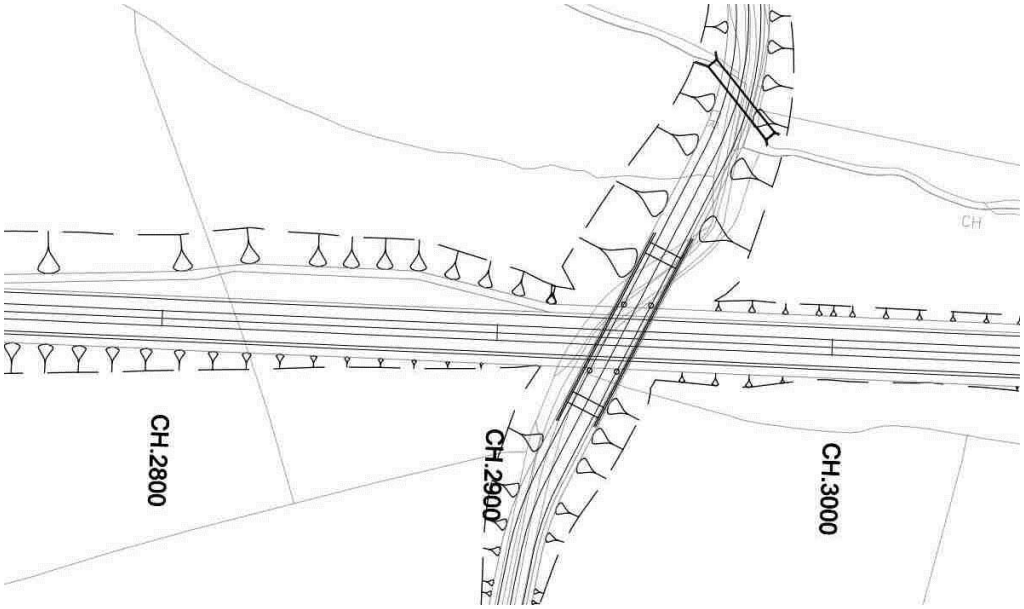
5.2.5.5 Recommendation

Incorporate in preliminary design.

5.2.6 Preliminary Design Option P13 - Pont Ceriw Overbridge (S109)

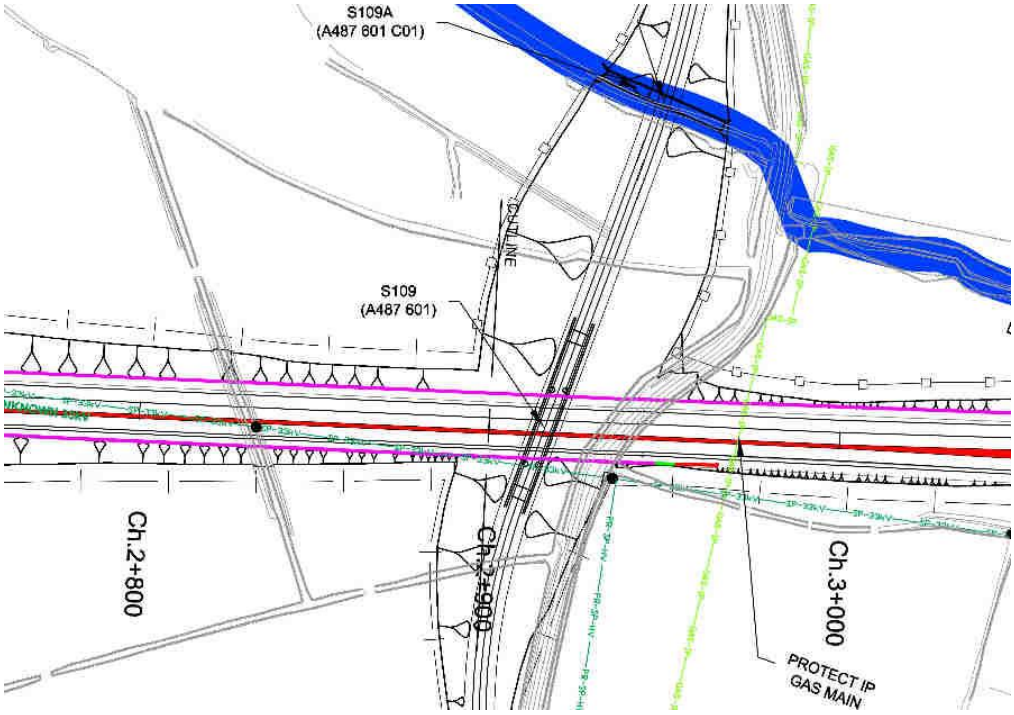
5.2.6.1 Description

The Tender Design included an online side road overbridge, however, the earthworks spilled over an intermediate pressure gas main and required the relocation of a 33kV diversion terminal pole and a skewed culverted watercourse crossing (see below).



This design option considers the relocation of the overbridge off-line to avoid affecting the existing utilities. Traffic data has also identified that the existing side road is very lightly trafficked, and therefore this design option also considered the closure of the road to vehicular traffic, and retaining the bridge for non-motorised users (pedestrians and cyclists only). Access for equestrians and vehicles would be maintained through a diversion along existing side roads.

The clearance required by standards for an NMU overbridge is greater, however the reduced width and structural form would be a significant reduction in cost.



5.2.6.2 Appraisal

Economy	Assessment / Comment	Significance
Transport Economic Efficiency -TEE	Vehicular diversion dis-benefits, reduced utilities costs, slight reduction structure costs	+
Wider Economic Impacts - EALI	No impact	0

Environment		
Noise	Traffic noise exchange side road/diversion	0
Local Air Quality	Marginal change side road /diversion	0
Greenhouse Gas Emissions	No impact	0
Landscape and Townscape	Marginal change	0
Bio-diversity	Northern hedgeline preserved habitat /connectivity	+
Heritage	No impact	0
Water Environment	No impact	0
Soils	Additional non-highway landtake	-

Society		
Transport Safety	Pedestrian / vehicle conflicts on side road removed	+
Personal security	No impact	0
Permeability	Vehicle movements diverted	-
Physical Fitness	Dedicated pedestrian route promotes walking/cycling	+
Social Inclusion	No impact	0
Equality, Diversity & Human Rights	No impact	0

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No impact	**0**
TPO2 - Llanwnda to Caernarfon JT	No impact	**0**
TPO3 - Traffic resident communities	Traffic exchange side road / diversion	**0**
TPO4 - Casualty reduction target	Marginal change side road / diversion	**0**
TPO5 - Network resilience / capacity	Side road closed, on bridge maintenance access reduced	**0**

Other Issues		
Health impact	Dedicated pedestrian route promotes walking/cycling	**+**
Stakeholder acceptability	WG/Sustrans support, landowner/Gwynedd potential issues	**0**
Technical and operational feasibility	Off-line construction, utilities safety	**+**
Affordability and deliverability	Reduced utilities works, slight reduction structure costs	**+**
Risk	Utilities risk reduced, Gwynedd Traffic Order required	**-**

5.2.6.3 Key advantages:

- Reduced utilities works / safety;
- Improved offline construction;
- Safer dedicated NMU route.

5.2.6.4 Key disadvantages:

- Vehicular diversion and equestrian diversion required;
- Side road approaches to the structure would not be in accordance with Disability Discrimination Act 1995;
- Gwynedd Council Traffic Order required.

5.2.6.5 Recommendation

Incorporate non-motorised users (NMU) bridge in preliminary design.

5.3 Drainage

5.3.1 Strategy

5.3.1.1 The highway surface water drainage strategy is for over the shoulder surface run-off into a verge swale, which when full discharges to a carrier/filter drain beneath the swale. The filter/carrier drain with intermediate verge catchpits outfalls via a penstock headwall to a toe-of-earthwork attenuation pond.

5.3.1.2 The attenuation ponds shown in the table below have 1:3 side slopes and are designed to contain a depth of 0.7m water, which represents a 1 in 100 year storm +30%, with 0.3m freeboard to the top of water level. The attenuation pond discharges via a wet well outlet headwall and 5l/s hydraulic throttle into the receiving watercourse. An overtopping spillway in the pond banking provides a surface discharge route in the event of outlet blockage.

Ref.	Chainage	Storage volume (m^3)	Ref.	Chainage	Storage volume (m^3)
Pond 1	0+480	389	Pond 8	5+630	966
Pond 2	1+360	1128	Pond 9	6+470	630
Pond 3	1+600	711	Pond 10	6+580	1219
Pond 4	3+200	640	Pond 11	8+110	445
Pond 4a	2+120	664	Pond 12	8+230	490
Pond 5	3+610	664	Pond 13	9+690	1441
Pond 6	4+120	994	Pond 14	7+190	200?
Pond 7	5+270	625			

5.3.1.3 Highway sub-surface drainage at the head of the network is captured in a verge fin drain outfalling into the first filter/carrier pipe catchpit. Where the filter/carrier drain is already present, sub-surface drainage is via sub-base extension to the filter/carrier drain.

5.3.1.4 Overland drainage run-off is captured in an un-lined cut-off ditch and routed to the nearest receiving watercourse. Where down-slope run-off capture is required a duplicate cut-off ditch detail is provided.

5.3.1.5 Main river flows and all cross culverts which have 150mm recessed gravel inverts have been hydraulically assessed but are typically sized more to meet environmental provision, shared use, or structural inspection and maintenance criteria.

5.3.2 Preliminary Design Option P14 - Culvert Sizing

5.3.2.1 Description

Due to the lack of detailed site information, the Tender Design minimised risk by retaining the 2.1m diameter pipes/culverts included in the Conceptual Design. The hydraulic analysis undertaken at Preliminary Design and aided by LIDAR catchment data and new topographical survey data shows that these sizes may be overly conservative.

A full hydraulic assessment for all land drainage / river catchments impacted by the bypass works was undertaken followed by consultation to determine non-hydraulic factors that may have impacted upon pipe/box culvert size. Some of the items considered during consultation were:

- Structure approval, maintenance & inspection requirements/preferences;
- Bat flightpath connectivity;
- Headroom constraint;
- Entry/exit river training geometry;
- Safety grill/trash screen requirement;
- Simplicity of forms;
- Combined use flood sensitivity;
- Statutory undertakers plant;
- Mammal shelf;
- Submerged invert/gravel bed.

The hydraulic assessment and non-hydraulic issues review suggested a family of three key pipe sizes:

- 1.8m - Serving main rivers & tributaries allowing manual inspection & bat use;
- 1.5m - Minimum size for manual inspection & bat use (at clearance constraint);
- 0.6m - Minimum size serving field ditches, no bat requirement.

The proposed pipe/box culvert sizes and results from the hydraulic assessment are given in the table below.

BBJV Ref.	Chainage	WG Asset No.	WG Name	Type	Min Hydraulic Size
S101	0+180	A487 550 C68	Ty Hên Culvert	1.8m Pipe	1.05m Pipe
S102	0+500	A487 565	Afon Rhyd Culvert	3.2x1.8m (WxH) Box Culvert	TBA
S104	1+400	A487 571 C80	Geufron Culvert	1.8m Pipe	1.2m Pipe
S109A	2+930(SR)	A487 601 C01	Pen Y Bryn Culvert 3	1.8m Pipe	1.2m Pipe
S109B	3+150	N/A	Pen Y Bryn Culvert 4	0.6m Pipe	TBA
S110A	3+560(SR)	A487601 C58	Pen Y Bryn Culvert 2	1.8m Pipe	1.05m Pipe
S110	3+682	A487 601 C73	Pen y Bryn Culvert 1	1.8m Pipe	1.05m Pipe
S111A	4+040	A487 611 C08	Bryn Mafon Culvert 1	1.8m Pipe	n/a Bat Culvert
S111B	4+070(SR)	A487 611 C09	Bryn Mafon Culvert 2	1.5m Pipe	1.05m Pipe
S112A	6+500(SR)	A487 621 C61	Bodrual Culvert 2	1.5m Pipe	0.75m Pipe
S112B	6+460	A487 621 C59	Bodrual Culvert 1	1.5m Pipe	0.75m Pipe
S112C	5+850	N/A	Cibyn Culvert 1	0.6m Pipe	TBA
S112D	5+970	N/A	Cibyn Culvert 2	0.6m Pipe	TBA
S113A	7+160	A487 625	FP 36	3.0x2.6m (WxH) Box Underbridge	0.7x0.3m (WxH) channel TBA
S114	8+160	A487 631	Afon Cadnant Cattle Creep / Culvert	3.4x3.4 (WxH) Box Underbridge	0.7x0.7m (WxH) channel TBA
S114A	8+180(SR)	A487 631 C08	Lon Glai Culvert	1.8m Pipe	TBA
S115A	8+400(SR)	A487 635 C01	Bethel Road Culvert 1	1.8m Pipe	TBA
S115B	8+490(SR)	A487 635 C03	Bethel Road Culvert 2	1.8m Pipe	TBA

5.3.2.2 Appraisal

Economy	**Assessment / Comment**	**Significance**
Transport Economic Efficiency -TEE	Reduced culvert costs, potential earthworks savings	**+**
Wider Economic Impacts - EALI	No impact	**0**

Environment		
Noise	No impact	**0**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	Reduced construction materials	**0**
Landscape and Townscape	Reduction headwall/earthworks visual intrusion	**+**
Bio-diversity	Reduced mammal/bat connectivity at 0.6m dia	**-**
Heritage	No impact	**0**
Water Environment	Gravel inverts retained	**0**
Soils	No impact	**0**

Society		
Transport Safety	No impact	**0**
Personal security	No impact	**0**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	No change	**0**
TPO5 - Network resilience / capacity	Reduced inspection requirement, additional screen maintenance 0.6m dia	**0**

Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	WG/TAA support, NRW possible bat issue	**-**
Technical and operational feasibility	Smaller/easier construction operations	**+**
Affordability and deliverability	Culvert cost savings	**+**
Risk	NRW approval / request additional crossing points	**-**

5.3.2.3 Key advantages:

- Reduced culvert costs;
- Reduction in vertical alignment constraints restoring earthwork flexibility;
- No Category 0 check required for 0.6m culvert.

5.3.2.4 Key disadvantages:

- Manual inspection / maintenance issues <0.9m;
- Reduced protected species connectivity, especially bats;
- Trash screen cost and on-going maintenance;
- Security screen risk appraisal, cost and on-going maintenance <0.6m.

5.3.2.5 Recommendation

Incorporate in preliminary design.

5.3.3 Preliminary Design Option P15 - Highway Drainage Infiltration

5.3.3.1 Description

The tender drainage proposal includes for positive capture of highway drainage in swales and piped networks involving significant capital cost / maintenance liability and does not take advantage of SUDS opportunities.

This design option considers draining the highway vertically through the porous embankment fill and then by direct infiltration into the existing ground beneath. New site investigation infiltration testing showed variable existing ground porosity such that this option could not be applied globally. There is also a risk of toe-of-earthwork seepage with consequential saturated ground and water capture/attenuation issues.

5.3.3.2 Recommendation

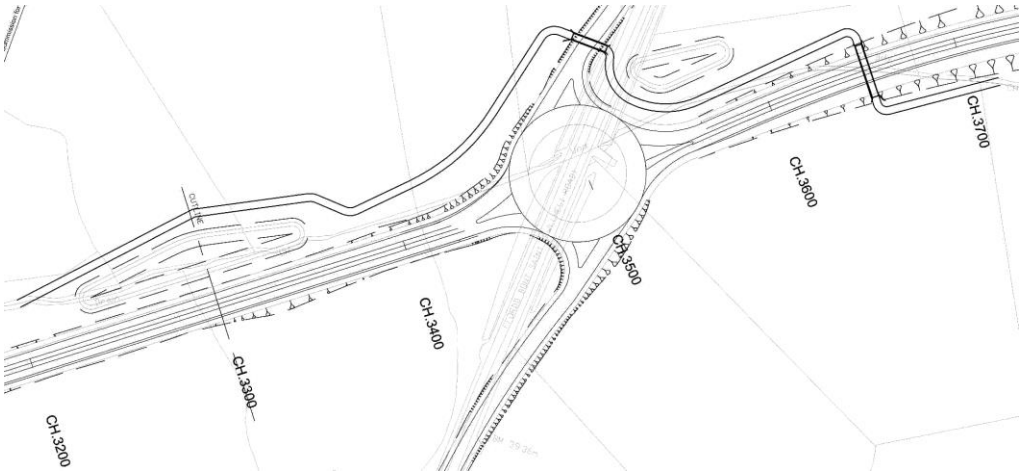
The WelTAG appraisal was curtailed because the option was not supported by site investigation infiltration test results, therefore not incorporated in preliminary design.

5.4 Value Engineering

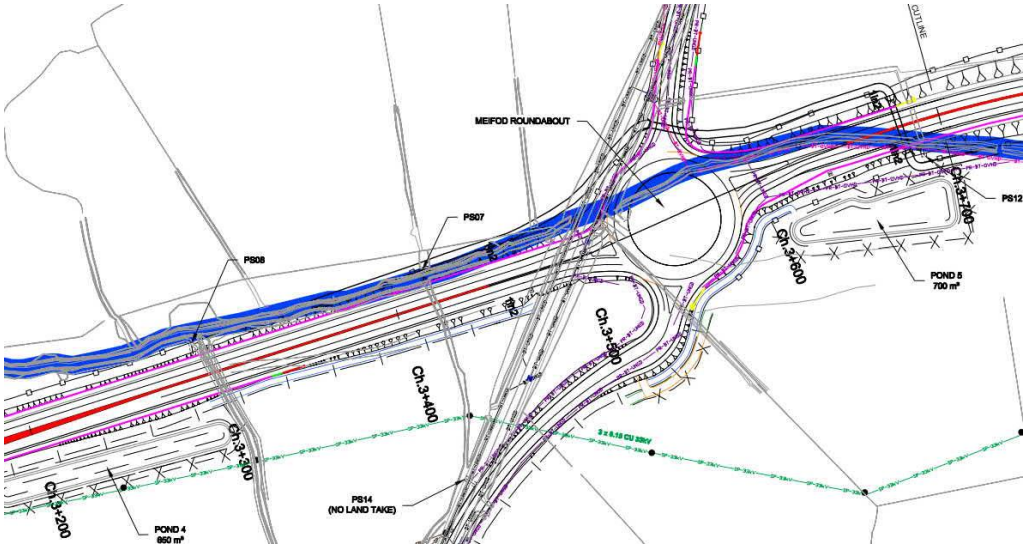
5.4.1 Preliminary Design Option P16 - Meifod Roundabout Relocation

5.4.1.1 Description

The Tender Design placed Meifod Roundabout centrally on the existing A487 (see below), which would have resulted in complex and disruptive traffic management during construction. In addition there would have been a number of programme risks associated with the works required to existing watercourse and statutory undertaker diversions running through middle of roundabout.



As a result, this design option considers the relocation of the roundabout, and these are detailed in Technical Note (3512874-PB-XX-XX-TN-J-00005). This preferred option (Option C) is for an approximate 70m shift further north (see below).



5.4.1.2 Appraisal

Economy	**Assessment / Comment**	**Significance**
Transport Economic Efficiency -TEE	Marginal cost increase, construction disruption saving	**0**
Wider Economic Impacts - EALI	No impact	**0**

Environment		
Noise	Marginal reduction, increased distance to receptors	**0**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	No impact	**0**
Landscape and Townscape	Reduced visual impact / better landscape fit esp. pond	**+**
Bio-diversity	Southern hedgeline preserved, habitat potential abandoned highway	**0**
Heritage	No impact	**0**
Water Environment	Reduced river training, pond location	**0**
Soils	Marginal, better use of severed land, landtake bias north	**0**

Society		
Transport Safety	Constrained Bontnewydd entry, improved exit geometries	**+**
Personal security	No impact	**0**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	Marginal, improved construction safety	**0**
TPO5 - Network resilience / capacity	New infrastructure, reduced maintenance	**0**

Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	WG/NRW support, Landowner/Gwynedd Council potential issues	**0**
Technical and operational feasibility	Construction TM safety / simplified watercourse diversion	**+**
Affordability and deliverability	Cost/programme savings	**+**
Risk	Gwynedd Council approval required (no change)	**0**

5.4.1.3 Key advantages:

- Reduced construction traffic management / disruption;
- Reduced length river training works;
- Better use of severed land in north-west quadrant.

5.4.1.4 Key disadvantages:

- Side road displacement, reduced approach geometry.

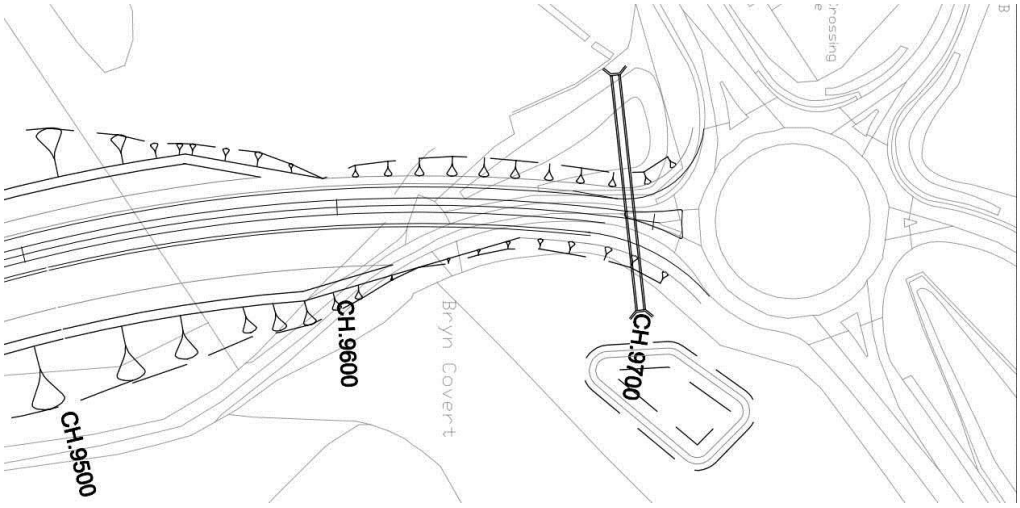
5.4.1.5 Recommendation

Incorporate in preliminary design.

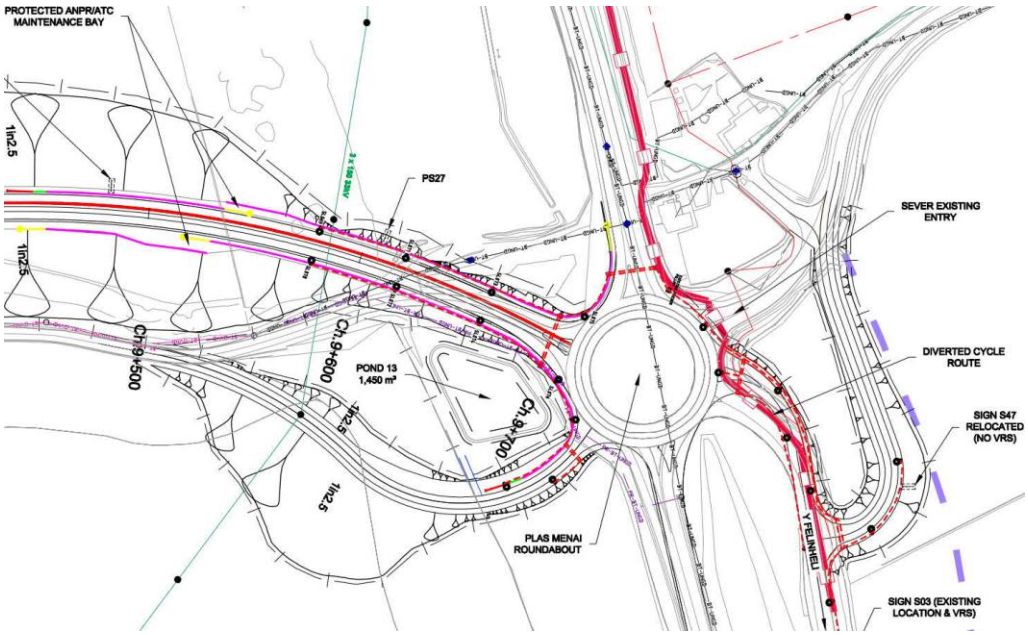
5.4.2 Preliminary Design Option P17 - Re-connection of Crug Lane

5.4.2.1 Description

Stakeholder consultation found that Crug Farm and Delsol were concerned about the proposed severing of Crug Lane link onto Plas Menai Roundabout and might be likely to object at Public Local Inquiry. Gwynedd Council also expressed concern that the severing of the link might adversely affect traffic patterns on the local road networks and particularly an increase in traffic through Bethel re-routing from the A487 to the B4366.



The Value Engineering workshop instructed investigation of several network re-connection options at Bethel Road, Plas Menai and combinations of both as detailed in study report (3513874-PB-XX-XX-RP-J-00012). The study resolved that the preferred option (Option 5A) was to re-establish the Crug Lane link and remodelling of Plas Menai to retain the existing 5 arm roundabout configuration.



5.4.2.2 Appraisal

Economy	Assessment / Comment	Significance
Transport Economic Efficiency -TEE	Moderate capital cost increase, re-allocated Caernarfon traffic on Crug Lane, low time savings	- -
Wider Economic Impacts - EALI	Easier business/customer access, may attract new business	+ +

Environment		
Noise	Slight increase construction noise existing receptors	**-**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	Slight increase excavation and processing of construction materials	**-**
Landscape and Townscape	Potential landscape views impact Bryn Covert cutting	**-**
Bio-diversity	Potential bat impacts, landtake & lighting	**- -**
Heritage	Potential archaeology impact	**-**
Water Environment	No impact	**0**
Soils	Slight additional landtake	**-**

Society		
Transport Safety	New priority junction with re-located uncontrolled crossing NCN 8. Improved access to pond.	**-**
Personal security	No impact	**0**
Permeability	No impact	**0**
Physical Fitness	Crug Lane will be open to pedestrians, equestrians and cyclists	**0**
Social Inclusion	Slight improvement access to Trunk Road and hence services	**+**
Equality, Diversity & Human Rights	No impact	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	Slight traffic re-routing, increase Bethel Road W, reduction A487(W) Caernarfon / Plas Menai	**0**
TPO4 - Casualty reduction target	NCN 8 roundabout uncontrolled at-grade crossing re-located to priority junction, improved visibility	**0**
TPO5 - Network resilience / capacity	No change	**0**

Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	Crug Farm / Delsol / Gwynedd Council support. NRW against	**- -**
Technical and operational feasibility	No impact	**0**
Affordability and deliverability	Moderate additional cost technically deliverable	**- -**
Risk	Environmental impact, PLI objection	**-**

5.4.2.3 Key advantages:

- Full 2-way re-connection of Crug Lane, no change access traffic;
- Enhanced Crug Lane alignment (60kph design speed);
- Retention of existing highway assets;
- Non-trunk road pond access;
- Minimal disruption to Trunk Road during construction.

5.4.2.4 Key disadvantages:

- Significant landtake from Bryn Covert bat habitat;
- Landtake northside Plas Menai;
- Potential safety issues Y-Felinheli priority junction;
- Construction disruption to Y-Felinheli & Yacht Club access;
- Intermediate Crug Lane link preludes future left filter to bypass.

5.4.2.5 Recommendation

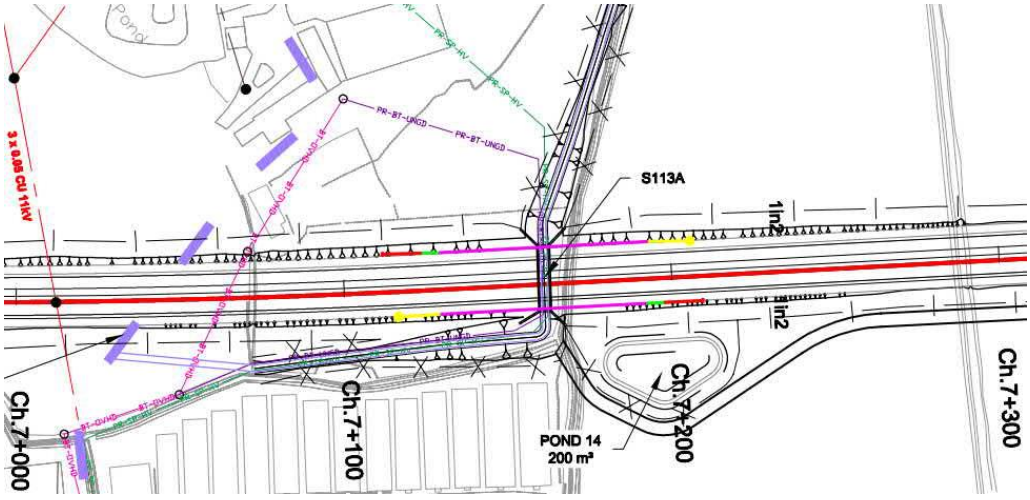
Incorporate in preliminary design.

5.4.3 Preliminary Design Option P18 - Re-connection of FP36 (S113A)

5.4.3.1 Description

Mandatory Assumption 8 stated that "All existing Rights of Way for NMUs that cross the proposed Bypass shall be maintained except for FP 36 which may be considered for stopping up". Early consultations showed that severance of FP36 would be an issue for Gwynedd Council, who would strongly prefer re-connection.

Consideration was given to how this public footpath could be retained. Due to the identification of additional culvert S113A for the connection of field drainage, it was concluded that this additional culvert could be increased in size to accommodate the public footpath as well.



5.4.3.2 Appraisal

Economy	Assessment / Comment	Significance
Transport Economic Efficiency -TEE	Additional underpass & attenuation pond costs	-
Wider Economic Impacts - EALI	No impact	0

Environment		
Noise	No impact	**0**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	Additional concrete/construction activity	**-**
Landscape and Townscape	Minimal, entrances in cutting	**0**
Bio-diversity	Additional mammal/bat connectivity (unlit preference)	**+ +**
Heritage	No impact	**0**
Water Environment	Additional attenuation pond, avoids pipe culverting	**+**
Soils	Additional landtake	**-**

Society		
Transport Safety	Without underpass pedestrians either divert to A4086 or may attempt at-grade bypass crossing, both unsafe	**+**
Personal security	Attack/vandalism risk if underpass unlit (preferred)	**-**
Permeability	Improved access/ options for walking	**+**
Physical Fitness	Footpath preserved, existing active lifestyles continue	**+**
Social Inclusion	Improved access/ options for walking	**+**
Equality, Diversity & Human Rights	No impact	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	Reduced risk uncontrolled crossing	**+**
TPO5 - Network resilience / capacity	No change	**0**

Other Issues		
Health impact	Removes closure impact on active lifestyle	**+**
Stakeholder acceptability	Gwynedd Council/ NRW/ Sustrans support	**+**
Technical and operational feasibility	Structure on trace, potential fill transport scheduling	**-**
Affordability and deliverability	Additional structure/drainage costs	**-**
Risk	Gwynedd Council / PLI objection reduced, right of way diversion required	**+**

5.4.3.3 Key advantages:

- Reconnects FP36, reduces PLI objection risk;
- FP36 diversion avoiding Tyddyn Bistle.

5.4.3.4 Key disadvantages:

- Additional structure/earthworks/drainage costs;
- Adds alignment ‘hard sport’ reducing flexibility for earthworks balance;
- Additional attenuation pond needed, carrier pipes can’t pass over structure;
- Significant landtake in entry/exit access ramps (approximately 70m at 1:20);
- Ditch channelised within underpass may flood FP36;
- If underpass requires lighting, poor bat performance.

5.4.3.5 Recommendation

Incorporate in preliminary design.

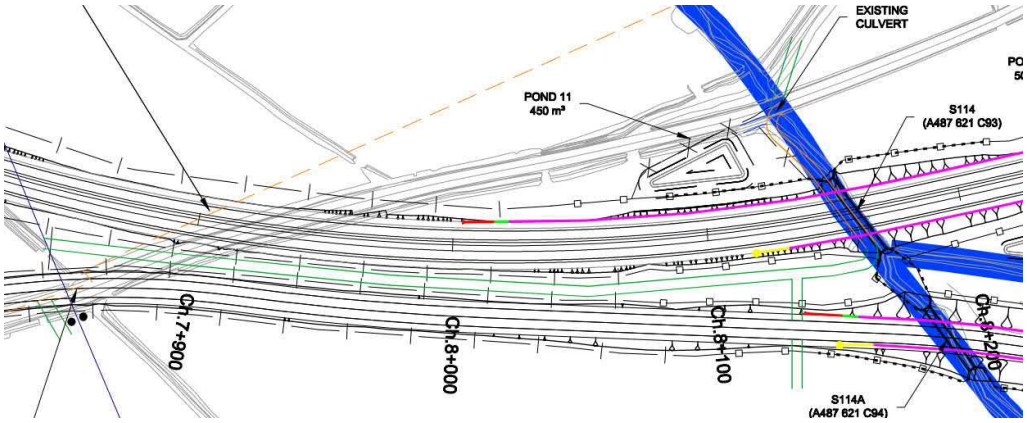
5.4.4 Preliminary Design Option P19 - Pengelli Isaf Farm Access (S114)

5.4.4.1 Description

Ongoing consultations with Pengelli Isaf Farm indicated their preference for a non-highway route for transporting cattle to the milking parlour. The Tender Design proposals would have required the transportation of cattle by vehicle which could have led to a potential objection at Public Local Inquiry.

This design option therefore considers the widening of the existing Afon Cadnant culvert (S114) to include a cattle creep, and the inclusion of associated private means of access routes to facilitate non-highway access to the various fields and milking parlour associated with Pengelli Isaf Farm.

This option would still necessitate a crossing of the realigned side road to the east.



An alternative solution for an accommodation overbridge at Ch.6+730 was also considered, however, this was discounted on grounds of whole life costs, maintenance, visual impact and land take for approach embankments.

5.4.4.2 Appraisal

Economy	Assessment / Comment	Significance
Transport Economic Efficiency -TEE	Additional cost wider box culvert, PMA (no change earthworks)	-
Wider Economic Impacts - EALI	Preserves viability of milking parlour	+

Environment		
Noise	No impact	**0**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	Increased construction materials	**-**
Landscape and Townscape	Minimal, buried entrances	**0**
Bio-diversity	Enhanced mammal/bat connectivity	**+**
Heritage	No impact	**0**
Water Environment	Minimal, trough rather than box culvert	**0**
Soils	Uses severed land	**0**

Society		
Transport Safety	Reduced cattle / roaduser conflicts	**+**
Personal security	No impact	**0**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	Slight reduction cattle/roaduser accidents	**+**
TPO5 - Network resilience / capacity	Reduced cattle movement disruption / road cleaning	**+**

Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	Landowner/NRW support	**+**
Technical and operational feasibility	Larger structure, wide trace for materials transport	**0**
Affordability and deliverability	Increased structure costs	**-**
Risk	Reduced risk landowner PLI objection	**+**

5.4.4.3 Key advantages:

- More direct / relaxed route for cattle to milking parlour;
- Reduced accident risk cattle / roaduser conflicts.

5.4.4.4 Key disadvantages:

- Additional cost of enlarged S114 culvert and private means of access.

5.4.4.5 Recommendation

Incorporate in preliminary design.

5.4.5 Preliminary Design Option P20 - Lay-by Provision

5.4.5.1 Description

Mandatory Assumption 16 required the pricing for four lay-bys, two in each direction for tender purposes, with the prospect of value engineering the provision during Key Stage 3. A survey of the existing provision on the A487 shows that there is currently one pair of lay-bys approximately 5km south of the bypass, and another pair approximately 5km east of the bypass.

TD69/07 clause 3.13 advises that lay-bys should be provided in each direction spaced between 2km and 5km apart. This is advice only, and not a mandatory requirement. This suggests that a pair of lay-by should be provided on bypass southern section and another pair on the bypass northern section as table below.

Northbound		
Lay-by	**Chainage**	**Spacing**
Existing	-5+000	
		7.5km
New	2+460	
		4.7km
New	7+115	
		5.1km
Existing	12+200	

Southbound		
Lay-by	**Chainage**	**Spacing**
Existing	-4+800	
		5.9km
New	1+120	
		7.1km
New	8+255	
		4.7km
Existing	13+000	

However the WS2+1 standard imposes a number of layout constraints which dictate that lay-bys can only be provided on the bypass northern section with departure from standard. TD 70/08 clause 4.21 requires a minimum separation of 375m between lay-bys and junctions, accesses, changeovers or WS2+1 interfaces.

Therefore between the end of the climbing lane and Cibyn Roundabout, TD 70/08 would require the following distances:

375m separation
325m lay-by length
375m separation
300m changeover length for switching of 2+1
375m separation
325m lay-by length
375m separation
Total = 2.45km

The climbing lane reaches a 2% gradient at Ch.8+810 and therefore the junction (end of climbing lane) is located at Ch.8+590 (220m passed the 2% point). Cibyn

Roundabout is located at Ch.6+560, therefore there is only 2.03km between these two features to fit in the two lay-bys, the changeover, and the necessary separations.

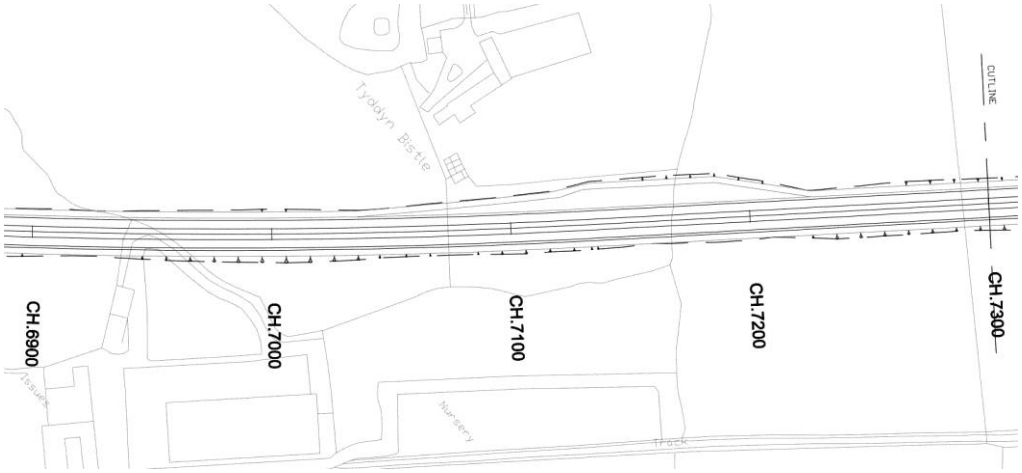
A departure from standard could be applied for to reduce the 375m separations between lay-bys and change-over length, however, this length would need to more than half to 175m, so is not considered acceptable on safety grounds.

Alternatively, the climbing lane length could be reduced by 420m, which would effectively halve its length by the application of a departure from standard. A climbing lane and the 2 lane section of a 2+1 are similar in section, if not use. However, three further issues would arise:

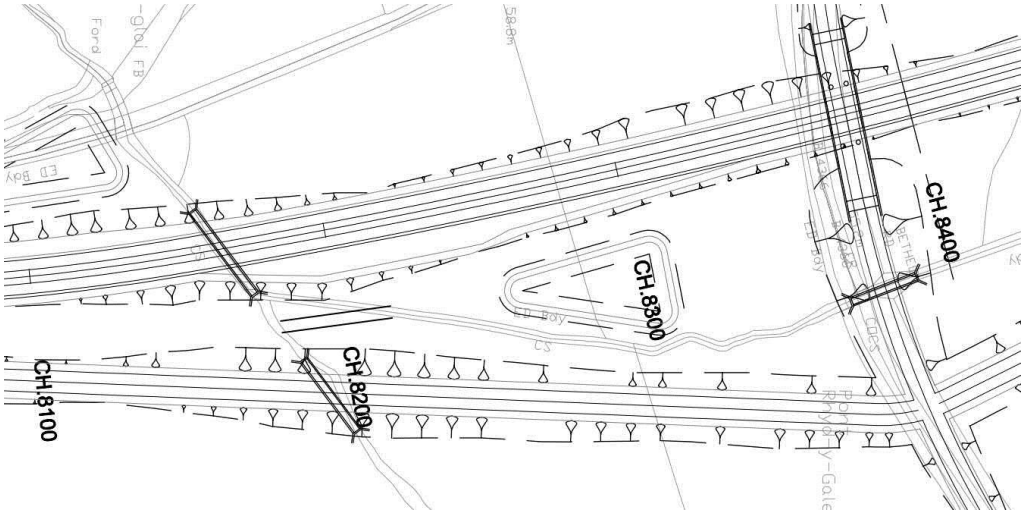
i) A northbound lay-by located at Ch.7+115 would be directly between Tyddyn Bistle and Kent farms, thereby increasing the impact on these properties (see below).

i) A southbound lay-by located at Ch.8+255 would be between culvert S114 & S115, so the lay-by tapers would increase the length of both culverts.

ii) This would be a second unavoidable departure in the vicinity, conflicting with the changeover curvature departure.



Northbound Lay-by Ch.7+115



Southbound Lay-by Ch. 8+255

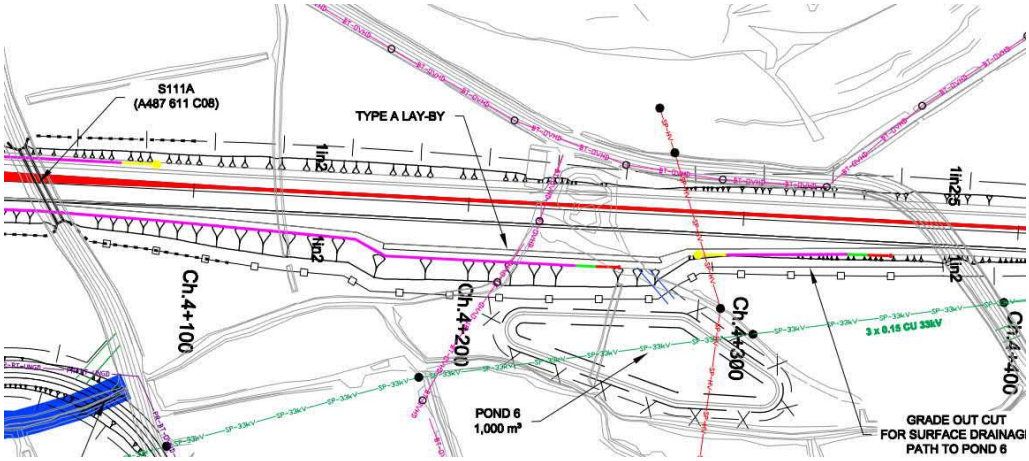
Preliminary design option P20 is therefore to reduce lay-by provision to only one lay-by in each direction, situated within the middle section of the bypass, as shown in the table below.

Northbound		
Lay-by	**Chainage**	**Spacing**
Existing	-5+000	
		10.8km
New	5+785	
		6.4km
Existing	12+200	

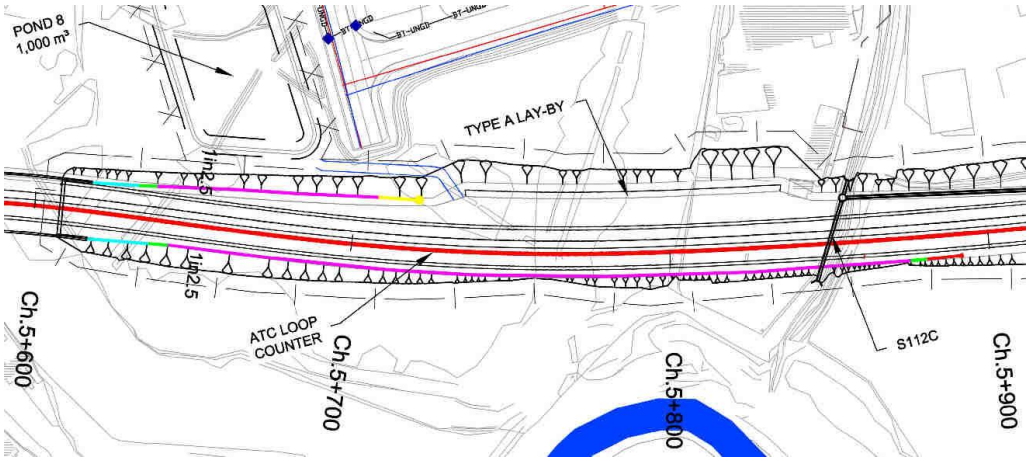
Southbound		
Lay-by	**Chainage**	**Spacing**
Existing	-4+800	
		9.0km
New	4+230	
		8.8km
Existing	13+000	

It should be noted that the lay-by standard TD69/07 does not recognise the conditions of the 2+1 standard TD70/08 and as such does not offer the Type A lay-by with merge taper for use on single carriageway roads. For the purposes of the Preliminary Design the dual carriageway Type A lay-by with merge taper is considered the appropriate lay-by layout for the 2 lane sections of the 2+1 bypass.

This proposal would not require any departures from standard, but would not meet the 2km to 5km spacing between lay-bys advised by TD69/07. It would also not be in accordance with Mandatory Assumption 16.



Proposed new southbound lay-by



Proposed new northbound lay-by

5.4.5.2 Appraisal

Economy	Assessment / Comment	Signifi cance
Transport Economic Efficiency -TEE	Reduced capital cost	+
Wider Economic Impacts - EALI	No impact	0

Environment		
Noise	Reduced impact Tyddyn Bistle and Kent farm receptors	0
Local Air Quality	No impact	0
Greenhouse Gas Emissions	Reduced construction materials	0
Landscape and Townscape	Reduced visual impact Tyddyn Bistle and Kent farms	+
Bio-diversity	No impact	0
Heritage	No impact	0
Water Environment	No impact	0

Soils	Reduced landtake	**+**

Society		
Transport Safety	Reduced frequency carriageway re-joining conflicts. Improved coordination with maintenance access	**+**
Personal security	No impact	**0**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	No change	**0**
TPO5 - Network resilience / capacity	Reduced maintenance liability, improved access	**+**

Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	Landowner/NRW support, WG/NMWTRA potential issues	**-**
Technical and operational feasibility	No impact	**0**
Affordability and deliverability	Cost savings	**+**
Risk	WG/NMWTRA acceptance required (not departure)	**-**

5.4.5.3 Key advantages:

- Avoids TD 70/08 minimum separation departure;
- Facilitates maintenance of middle section traffic loops (terminals at Automatic Number Plate Recognition locations);
- Both lay-by dual as pond access points (Ponds 6 & 8);
- Reduced landtake / adjacent property intrusion.

5.4.5.4 Key disadvantages:

- Reduced (less than tender) lay-by provision on TD69/07 advice.

5.4.5.5 Recommendation

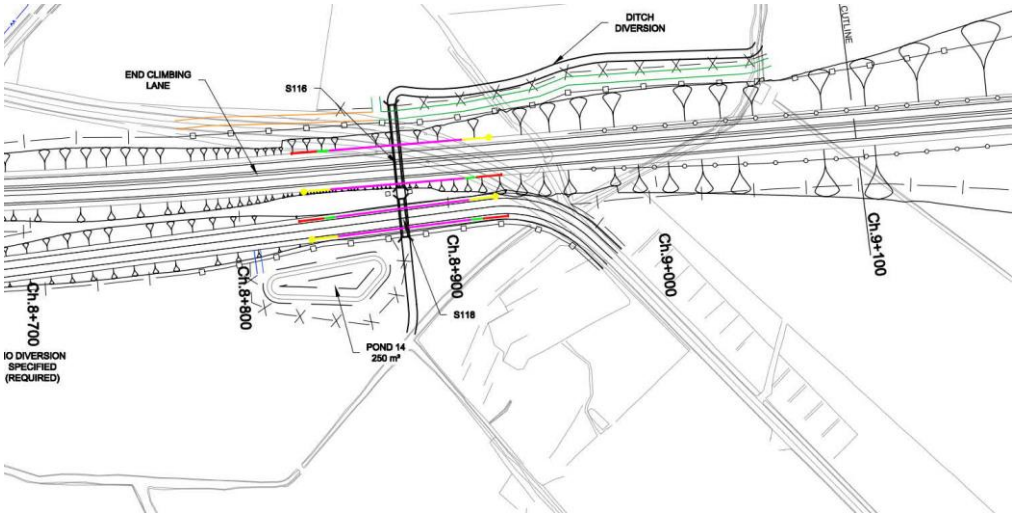
Incorporate in the Preliminary Design.

5.4.6 Preliminary Design Option P21 - Caerlan Tibot Culverts (S116 & S118)

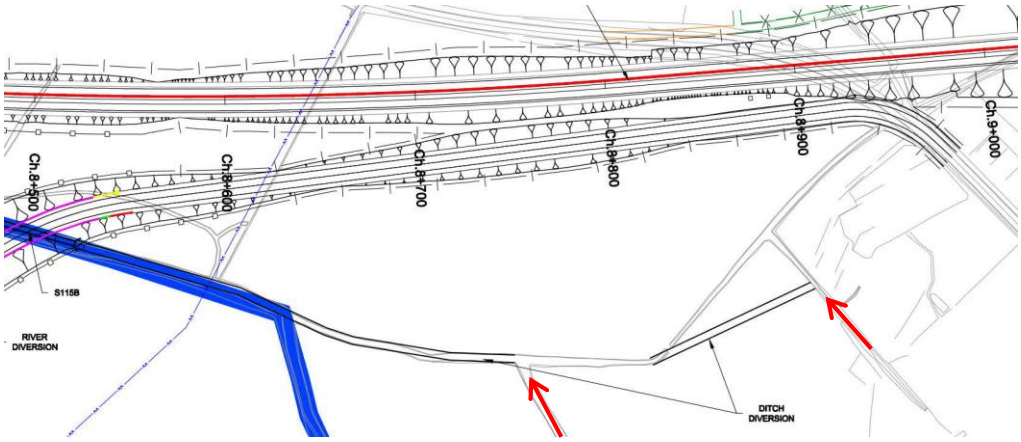
5.4.6.1 Description

At Tender Design culverts S116 and S118 were headroom constrained by the bypass vertical alignment at the top end of the Plas Menai cutting. Consequently the ditch

diversion was pushed further south resulting in an approximately 5m deep ditch along the western fenceline to reconnect with the existing ditch (see below).



This design option considers the capture of ditch flows to the east of the bypass and diverting these flows south in a re-graded ditch to outfall into the Afon Cadnant tributary and ultimately Afon Cadnant at S114 (see below).



5.4.6.2 Appraisal

Economy	Assessment / Comment	Significance
Transport Economic Efficiency -TEE	Culverts removed, reduced capital / maintenance cost	+
Wider Economic Impacts - EALI	No impact	0

Environment		
Noise	No impact	**0**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	Reduced construction materials	**+**
Landscape and Townscape	Slight improvement, culvert, VRS & deep outfall ditch removed	**+**
Bio-diversity	Positive drainage may impact wetland habitat	**-**
Heritage	No impact	**0**
Water Environment	Open watercourse, water capture into Cadnant	**-**
Soils	Reduced landtake especially on the westside deep ditch cut	**+**

Society		
Transport Safety	No impact	**0**
Personal security	No impact	**0**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	No change	**0**
TPO5 - Network resilience / capacity	Reduced inspection/maintenance liability	**+**

Other Issues		
Health impact	No change	**0**
Stakeholder acceptability	WG/TAA/landowner support, NRW potential habitat/flooding issues	**0**
Technical and operational feasibility	May need update Cadnant flooding assessment	**-**
Affordability and deliverability	No change	**0**
Risk	NRW approvals	**-**

5.4.6.3 Key advantages:

- Removes culverts S116 & S118;
- Removes requirement for Pond 14, drainage continues through into cut;
- Avoids landtake and works for original deep outfall ditch;
- Ditch re-grading provides positive drainage to waterlogged ground.

5.4.6.4 Key disadvantages:

- Introduces cross catchment transfer and therefore additional Afon Cadnant catchment/flow which may hinder NRW approval;
- Removes wildlife crossing benefit offered by S116 & S118 (0.6m diameter);
- Ditch re-grading works, ≈300m with 0.5m deeper invert;
- Change in habitat due to positive drainage;
- Existing Crug Farm culvert to be grouted to prevent water seepage into cutting.

5.4.6.5 Recommendation

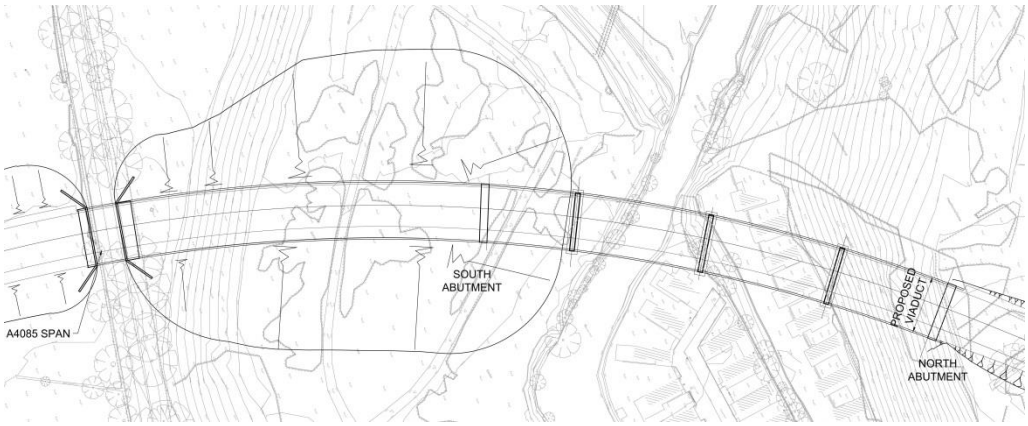
Incorporate in the Preliminary Design, but this option may need to be revised following feedback received from NRW on 12th June 2015, regarding cross catchment transfer to the Cadnant tributary and the need for flood modelling.

5.4.7 Preliminary Design Option P22 - Seiont Viaduct Span (S112)

5.4.7.1 Description

A value engineering opportunity has been recognised to potentially reduce the mandated length of Seiont Viaduct.

Flood modelling work has been undertaken of the Afon Seiont and has shown that the flood plain does not extend onto the plateau to the south of the river. Consideration has therefore been given to replacing part of the southern section of the viaduct with an impermeable embankment (see below).



This design option considers placing the bypass on embankment between the existing A4085 and the Afon Seiont with 1:2 side slopes, and the provision of a 4-span viaduct of approximately 148m overall length over the remaining river valley.

Additional culverts may be required through the embankment to maintain bat flightpaths.

5.4.7.2 Appraisal

Economy	**Assessment / Comment**	**Significance**
Transport Economic Efficiency -TEE	Reduced structure costs, increased fill	**+**
Wider Economic Impacts - EALI	No impact	**0**

Environment		
Noise	Potential beneficial, less propagation on embankment	**+**
Local Air Quality	No impact	**0**
Greenhouse Gas Emissions	Fewer concrete materials, more fill transport	**0**
Landscape and Townscape	Slight beneficial, embankment mitigation	**+**
Bio-diversity	No impact	**0**
Heritage	No impact	**0**
Water Environment	No impact	**0**
Soils	Landtake embankment	**-**

Society		
Transport Safety	No impact	**0**
Personal security	No impact	**0**
Permeability	No impact	**0**
Physical Fitness	No impact	**0**
Social Inclusion	No impact	**0**
Equality, Diversity & Human Rights	No impact	**0**

Transport Planning Objectives		
TPO1 - Llanwnda to Plas Menai JT	No change	**0**
TPO2 - Llanwnda to Caernarfon JT	No change	**0**
TPO3 - Traffic resident communities	No change	**0**
TPO4 - Casualty reduction target	Marginal saving, earthwork verge enhanced safety reserve, increased maintenance risks	**0**
TPO5 - Network resilience / capacity	Reduced structure maintenance	**+**

Other Issues		
Health impact	No impact	**0**
Stakeholder acceptability	NRW against, landowner possibly against, WG/TAA for	**-**
Technical and operational feasibility	Less challenging, craneage, piers, infrastructure maintenance safety concern on short high embankment between two minimum width verges	**+**
Affordability and deliverability	Reduced cost	**+**
Risk	NRW approval, insufficient fill	**- -**

5.4.7.3 Key advantages:

- Reduced structure Capital Cost but additional earthwork, culvert, fencing costs;
- Reduce structure whole life costs;
- Reduced A4085 overbridge width due to reduced visibility requirement from separating this short structure from Seiont viaduct structure;
- Relocate vertical sag onto new earthwork, thus easing A4085 clearance and highway drainage;
- Additional screening & new bat flightpath opportunities.

5.4.7.4 Key disadvantages:

- NRW objection (on bat flightpaths not flood level impact);
- Additional landtake, for earthwork & re-located pond 7.

5.4.7.5 Recommendation

This value engineering proposal still requires substantiation through further design and stakeholder consultation, and if still considered feasible, may be developed through the remainder of Key Stage 3 as the preferred option.

At present, this option is not incorporated in the Preliminary Design.

5.5 Preliminary Design Option Summary

5.5.1 Overall

5.5.1.1 The key design development proposals since the Tender Design are reflected in the Preliminary Design drawings (Appendix C) and Draft Layout Approval Drawings (Appendix D) and are summarised ase:

- Minor horizontal alignment shifts (within the TR111 corridor) at Gwyrfai floodplain, Cibyn Industrial Estate and Crug Farm;
- Vertical alignment amendments including removal of K=55 crests to realise visibility relaxations, and an optimised earthworks balance;
- All embankment side slopes retained at 1:2, but all cut slopes at 1:2.5, and no proposed return to agriculture included;
- Pipe culverts reduced from 2.1m diameter to 0.6m, 1.5m and 1.8m diameter, depending on hydraulic assessment and additional purpose;
- Existing side road pavement width preserved on approach and through structures, and structure verges reduced to minimum;
- Lay-by provision reduced to one lay-by in each direction located on bypass middle section;
- No street lighting at Meifod and Cibyn Roundabouts or Bethel Road junction, but full standard Goat & Plas Menai Roundabouts;
- Dinas Farm access restored to underbridge;
- Pont Cefnwerthyd Underbridge span reduced by inclusion of Welsh Highland Railway landtake and the introduction of two level crossings for a private means of access;
- Pont Ceriw Overbridge re-located offline & restricted to NMU use;
- Meifod Roundabout re-located off-line approximately 70m to the north;
- FP36 retained through a new box underbridge;
- Pengelli Isaf Farm cattle creep and private means of access added;

- Caerlan Tibot Culverts exchanged for cross-catchment capture into Afon Cadnant;
- Crug Lane re-connected into Plas Menai Roundabout with additional merge of Yacht Club and Y-Felinheli roundabout arms.

5.5.1.2 Although Preliminary Design Option P10 (Gwyrfai Viaduct Span (S106)) is not incorporated in the preliminary design proposals, it is the preferred solution. It is currently undergoing further substantiation through further design and stakeholder consultation, and if still considered feasible, may be developed through the remainder of Key Stage 3 as the preferred option.

5.5.1.3 Similarly, although Preliminary Design Option P22 (Seiont Viaduct Span (S112)) is not incorporated in the preliminary design proposals, it is the preferred solution. It is currently undergoing further substantiation through further design and stakeholder consultation, and if still considered feasible, may be developed through the remainder of Key Stage 3 as the preferred option.

5.5.2 Environment

5.5.2.1 The landscape design developed during the preliminary design continues to take into account the objectives (refer to section 4.2.1.1) and the perceived effects of the wider environmental mitigation and the results of the Key Stage 2 study.

5.5.2.2 In more detail particular attention has been given to a number of features. First of these has been the mitigation developed for bats, in particular the Lesser Horseshoe bat. The Scheme area has been described as a “bat landscape” and therefore every effort is made to mitigate the effects of the Scheme on the bat population and its activities. This has included the use of oversized culverts throughout the Scheme including specific structures for bats to move through the Scheme (e.g. S111A). This is supported by the use of temporary fencing to guide the bats during construction, whilst mitigation planting becomes established, together with the retention of existing vegetation to supplement new planting.

5.5.2.3 This approach also incorporates provision for otters in the area with culverts having a multi-function role. Otter-proof fencing will be provided to help guide the animals to the crossing points.

5.5.2.4 The preliminary design proposals have also taken on board the requirements of the EU Water Framework Directive. Essentially these are concerned with water quality, biological quality and the use of soft engineering in terms of drainage design. The Scheme makes extensive use of grass swales for primary drainage adjacent to the road and these are supported by a system of balancing ponds to control flow. In addition all culverts which include water courses will have bioengineered bases to allow for fish to pass through the structures.

5.5.3 Earthworks - Cuttings

5.5.3.1 In the Tender Design, the earthworks design profile for the cuttings, excluding the Plas Menai Cutting, was based on extremely limited published geological information, (the most recent British Geological Society mapping being dated 1852), no intrusive ground investigation, and unpublished data. The Tender Design adopted the Conceptual Design assumption of 1:2 slopes through the cuttings, which were largely to be within glacial till materials. It was assumed for tender that the shear strength of the superficial deposits would be sufficient for the proposed side slopes to remain stable without any additional engineering.

5.5.3.2 Ongoing intrusive ground investigation data has provided details of the superficial and solid geology in the area of the cuts. This has been supplemented, to date, by limited laboratory analysis. The results of the ground investigation have resulted in a revision of the Preliminary Design to accommodate the ground conditions.

5.5.3.3 While the ground investigation confirmed the presence of glacial till within the proposed cutting alignments; the insitu testing and laboratory testing available at the time of writing has indicated that the shear strength of the glacial tills, along with the ground water regime, may not be sufficient to allow the adoption of the Tender Design 1:2 side slopes. In order to test this, a preliminary slope stability assessment has been undertaken on the cuttings, this has indicated that in the long term effective stress regime, the cuttings do not remain stable. Two options were considered for the Preliminary Design: 1:2 slopes with side slope drainage, or 1:2.5 slopes. The later was adopted for the following reasons:

- 1:2.5 side slopes require less maintenance, could be grassed, and are easier and safer to inspect and maintain;
- Natural slopes in the area of the cut are generally low angle, therefore the 1:2.5 slopes are more in keeping with the landscape;
- No requirement to maintain slope drainage, thereby reducing the whole life cost.

5.5.4 Earthworks - Embankments

5.5.4.1 In the Tender Design, the earthworks design profile for the side slopes of the embankments adopted the Conceptual Design for 1:2 side slopes. This was based upon unpublished information that identified a number of areas as having weak and/or compressible ground beneath the proposed earthworks. An allowance was made in these areas to excavate up to 1.0m of the weak and compressible soils and replace with suitable granular fill.

5.5.4.2 Ongoing intrusive ground investigation data has provided details of the superficials in the area of the embankments, this has been supplemented, to date, by laboratory data that is currently available. The results of the ground investigation, to date, have generally supported the proposed Tender Design earthworks approach, and therefore these are unchanged in the Preliminary Design.

5.5.4.3 Once the ground investigation has been completed and a full interpretation has been undertaken further areas requiring formation treatment may become apparent. Should soft and compressible material be encountered that extend to a greater depth than it is economical to excavate and replace other options are available to treat the ground. These include the use of a load transfer platform, vibro stone or concrete columns, band drains and surcharge, etc.. It should be noted that the ground investigation to date has not identified the requirement for any of these techniques.

5.5.5 Highway Strategy

5.5.5.1 The highway strategy is based on the project brief and is documented in various technical notes prepared during Preliminary Design covering topics such as Junctions, Alignment, Visibility, Drainage, Lighting and Signing. These notes were used to inform the appropriate Technical Working Groups and discipline workshops where issues were discussed, options identified and passed for further appraisal. If necessary, further consultation was undertaken, before the final options were agreed by the project team.

5.5.6 WelTAG Appraisal

5.5.6.1 The following table includes a summary of WelTAG significant assessment for all the Preliminary Design options and whether they recommended for inclusion in the Preliminary Design.

Preliminary Design Option WelTAG Significance/Adoption Summary

		Economy		Environment								Social						Transport Planning Objectives					Other Issues					
Ref	Option	Transport Economic Efficiency -TEE	Wider Economic Impacts - EALI	Noise	Local Air Quality	Greenhouse Gas Emissions	Landscape and Townscape	Bio-diversity	Heritage	Water Environment	Soils	Transport Safety	Personal security	Permeability	Physical Fitness	Social Inclusion	Equality, Diversity & Human Rights	TPO1 - Journey time / reliability Llanwnda to Plas Menai	TPO2 - Journey time / reliability Llanwnda to Caernarfon	TPO3 - Reduce vehicles in communities	TPO4 - Casualty reduction targets	TPO5 - Improve network resilience / capacity	Health impact	Stakeholder acceptability	Technical and operational feasibility	Affordability and deliverability	Risk	Adopt
P01	Plas Menai Cut	0	0	0	0	-	+ +	+	0	+	-	+	0	0	0	0	0	0	0	0	0	+	0	0	0	-	+	✓
P02	Removal of Return to Agriculture	-	0	0	0	0	-	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	✓
P03	Landslip/Quarry Clearance	WelTAG appraisal curtailed																										×
P04	Crug Farm Landtake	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	0	+	✓
P05	Removal K=55 crests	-	0	0	0	0	0	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0	0	+	0	0	+	✓
P06	Side Road Section	+	0	0	0	0	+	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0	0	+	0	+	0	✓
P07	Reduced Road Lighting	0	0	0	0	0	+	+	0	0	0	-	-	0	0	0	0	0	0	0	-	0	0	-	0	0	-	✓
P08	Removal of Underpass Lighting	0	0	0	0	0	0	+	0	0	0	0	-	0	0	-	0	0	0	0	0	0	0	+	0	0	0	✓
P09	Gwyrfai Viaduct Position (S106)	+	0	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	+	+	0	+ +	✓
P10	Gwyrfai Viaduct Span (S106)	+	0	+	0	0	+	0	0	-	-	0	0	0	0	0	0	0	0	0	0	+	0	-	+	+	- -	×

		Economy		Environment								Social						Transport Planning Objectives					Other Issues					
Ref	Option	Transport Economic Efficiency -TEE	Wider Economic Impacts - EALI	Noise	Local Air Quality	Greenhouse Gas Emissions	Landscape and Townscape	Bio-diversity	Heritage	Water Environment	Soils	Transport Safety	Personal security	Permeability	Physical Fitness	Social Inclusion	Equality, Diversity & Human Rights	TPO1 - Journey time / reliability Llanwnda to Plas Menai	TPO2 - Journey time / reliability Llanwnda to Caernarfon	TP03 - Reduce vehicles in communities	TPO4 - Casualty reduction targets	TPO5 - Improve network resilience / capacity	Health impact	Stakeholder acceptability	Technical and operational feasibility	Affordability and deliverability	Risk	Adopt
P11	Restore Dinas Underbridge (S105)	0	0	+	0	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	0	+	✓
P12	Pont Cefnwerthyd Span (S108)	+	0	0	0	+	0	-	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	-	+	+ +	-	✓
P13	Pont Ceriw Overbridge (S109)	+	0	0	0	0	0	+	0	0	-	+	0	-	+	0	0	0	0	0	0	0	+	0	+	+	-	✓
P14	Culvert Sizing	+	0	0	0	0	+	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	+	+	-	✓
P15	Highway Drainage Infiltration	WelTAG appraisal curtailed																										×
P16	Meifod Roundabout Relocation	0	0	0	0	0	+	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0	0	0	+	+	0	✓
P17	Re-connection of Crug Lane	- -	+ +	-	0	-	-	- -	-	0	-	-	0	0	0	+	0	0	0	0	0	0	0	- -	0	- -	-	✓
P18	Re-connection of FP36 (S113A)	-	0	0	0	-	0	+ +	0	+	-	+	-	+	+	+	0	0	0	0	+	0	+	+	-	-	+	✓
P19	Pengelli Isaf Farm Access (S114)	-	+	0	0	-	0	+	0	0	0	+	0	0	0	0	0	0	0	0	+	+	0	+	0	-	+	✓
P20	Lay-by Provision	+	0	0	0	0	+	0	0	0	+	+	0	0	0	0	0	0	0	0	0	+	0	-	0	+	-	✓
P21	Caerlan Tibot Culverts (S116 & S118)	+	0	0	0	+	+	-	0	-	+	0	0	0	0	0	0	0	0	0	0	+	0	0	-	0	-	✓

		Economy		Environment								Social						Transport Planning Objectives					Other Issues					
Ref	Option	Transport Economic Efficiency -TEE	Wider Economic Impacts - EALI	Noise	Local Air Quality	Greenhouse Gas Emissions	Landscape and Townscape	Bio-diversity	Heritage	Water Environment	Soils	Transport Safety	Personal security	Permeability	Physical Fitness	Social Inclusion	Equality, Diversity & Human Rights	TPO1 - Journey time / reliability Llanwnda to Plas Menai	TPO2 - Journey time / reliability Llanwnda to Caernarfon	TP03 - Reduce vehicles in communities	TPO4 - Casualty reduction targets	TPO5 - Improve network resilience / capacity	Health impact	Stakeholder acceptability	Technical and operational feasibility	Affordability and deliverability	Risk	Adopt
P22	Seiont Viaduct Span (S112)	+	0	+	0	0	+	0	0	0	-	0	0	0	0	0	0	0	0	0	0	+	0	-	+	+	- -	×

5.6 Departures from Standard

5.6.1.1 Departures will be documented in full in the Departures from Standard Report however certain features of the Preliminary Design will require departures from standard:

No.	Departure from Standard	Initially identified at
1	Departure from TD 70/08 clause 3.9, for the location of a 2+1 conflicting crossover in the northern section on a curve of radius >=2880m.	Conceptual Design
2	Departure from TD 70/08 clause 3.11, for the location of a WS2+1 interface on a curve of radius >=720m on the southbound carriageway near Plas Menai Roundabout.	Conceptual Design
3	Departure from TD 27/05 clauses 4.2.1 and 4.7.2, for the reduced side road carriageway, hard strip, and verge widths.	Conceptual Design
4	Departure from TD 27/05 clause 4.11.13, for the reduced VRS set back at Bethel Road B4366 overbridge.	Tender Design
5	Departure from TD 42/95 clauses 7.5 and 7.6, for the reduced visibility at Bethel Road (B4366) crossroads.	Tender Design
6	Departure from TD34/97 clause 3.13 for no lighting & clause 3.19 for unlit gap at Meifod and Cibyn Roundabouts.	Preliminary Design

5.7 Risk

5.7.1.1 The Preliminary Design development has been chiefly guided by new data sources and stakeholder consultations to identify/allow for key constraints and reduce potential Public Local Inquiry objections. In doing so the overall scheme risk has again been significantly reduced. The key scheme risk remains confirmation of orders at Public Local Inquiry, but Preliminary Design development has helped highlight several other significant risks that remain at this point in the project:

- Natural Resources Wales acceptance of flood modelling and proposed mitigation measures;
- Statutory consultee acceptance of proposed environmental mitigation to be presented in the Environmental Statement;
- Confirmation of geotechnical conditions based on the preliminary findings from the on-going site investigations;
- Welsh Highland Railway and Office of Rail Regulation acceptance of revised proposals, including additional level crossing proposal;
- Agreement with highway authority on side road proposals, especially departures from standard (on lighting and side road standards and design speeds) and proposed road closures;
- Landowner acceptance of proposed private means of access.

6 LAYOUT APPROVAL

6.1 Design Proposals

6.1.1.1 The design features following the proposed design strategy and adopted highway design options detailed in this report form the coordinated scheme design that will be presented at 1:2,500 Layout Approval following acceptance of this report. Draft Layout Approval Plans are included in Appendix D.

6.1.1.2 1:2,500 Layout Approval will be sought following acceptance of this report.

APPENDIX A - CONCEPTUAL DESIGN DRAWINGS

Yellow Route TR111
Key Stage 2 TAR Highway Plan & Longsection Drawings
Key Stage 2 TAR Structure Layout Drawings

APPENDIX B - TENDER DESIGN DRAWINGS

Typical Cross Section Details	3513874-PB-XX-XX-DR-J-00001
Layout Sheet 1 of 11	14014-PB-06-11-DR-C-0001
Layout Sheet 2 of 11	14014-PB-06-22-DR-C-0001
Layout Sheet 3 of 11	14014-PB-06-33-DR-C-0001
Layout Sheet 4 of 11	14014-PB-06-39-DR-C-0001
Layout Sheet 5 of 11	14014-PB-06-51-DR-C-0001
Layout Sheet 6 of 11	14014-PB-06-63-DR-C-0001
Layout Sheet 7 of 11	14014-PB-06-68-DR-C-0001
Layout Sheet 8 of 11	14014-PB-06-78-DR-C-0001
Layout Sheet 9 of 11	14014-PB-06-84-DR-C-0001
Layout Sheet 10 of 11	14014-PB-06-91-DR-C-0001
Layout Sheet 11 of 11	14014-PB-06-98-DR-C-0001
Longitudinal Alignment	14014-PB-06-ZZ-DR-C-0007
Structure Location Plan	14014-PB-17-ZZ-DR-S-0005

APPENDIX C - PRELIMINARY DESIGN DRAWINGS

Longitudinal Alignment	3513874-PB-06-ZZ-DR-J-00001
Structure Location Plan	3513874-PB-XX-XX-DR-S-00001

APPENDIX D - DRAFT LAYOUT APPROVAL PLANS

Layout Approval Sheet 1 of 9	3513874-PB-06-XX-DR-J-00001
Layout Approval Sheet 2 of 9	3513874-PB-06-XX-DR-J-00002
Layout Approval Sheet 3 of 9	3513874-PB-06-XX-DR-J-00003
Layout Approval Sheet 4 of 9	3513874-PB-06-XX-DR-J-00004
Layout Approval Sheet 5 of 9	3513874-PB-06-XX-DR-J-00005
Layout Approval Sheet 6 of 9	3513874-PB-06-XX-DR-J-00006
Layout Approval Sheet 7 of 9	3513874-PB-06-XX-DR-J-00007
Layout Approval Sheet 8 of 9	3513874-PB-06-XX-DR-J-00008
Layout Approval Sheet 9 of 9	3513874-PB-06-XX-DR-J-00009

Appendix A.6 Structures Design Options Report

A487 CAERNARFON TO BONTNEWYDD BYPASS

STRUCTURES DESIGN OPTIONS REPORT

Welsh Government

3513874-PB-XX-XX-RP-S-00001

Final

A487 Caernarfon to Bontnewydd Bypass

STRUCTURES DESIGN OPTIONS REPORT

3513874-PB-XX-XX-RP-S-00001



Report Title	:	**A487 Caernarfon to Bontnewydd Bypass STRUCTURES DESIGN OPTIONS REPORT**
Doc Number	:	**3513874-PB-XX-XX-RP-S-00001**
Report Status	:	**Final**
Job No	:	**3513874A-HHC**
Date	:	**June 2015**

DOCUMENT HISTORY AND STATUS

Document control			
Prepared by	A K Groves	**Checked by** *(technical)*	A M Jarman
Approved by	R Bennett	**Checked by** *(quality assurance)*	K Attwood

Revision details			
Version	**Date**	**Pages affected**	**Comments**
P1.0	12/06/15	All	First Issue
P2.0	21/09/15	All	Final Issue

CONTENTS

		Page
1	**EXECUTIVE SUMMARY**	**1**
1.1	Background and Context	1
1.2	The Scheme	1
1.3	This Report	2
1.4	Summary and Recommendations for Structures along the Scheme	3
2	**THE PROJECT**	**7**
2.1	Context	7
2.2	Background	7
2.3	The Scheme	8
2.4	Project Objectives and Reason for Project	9
3	**PURPOSE OF THIS REPORT**	**11**
3.1	Introduction	11
3.2	Location Plan and Structures	12
4	**CONTEXT FOR STRUCTURES**	**15**
4.1	Introduction	15
4.2	Key Stage 2 Report	15
4.3	Highway Alignment and Earthworks Balance	15
4.4	Aesthetics and Landscape Effects	16
4.5	Highway Interfaces	17
4.6	Statutory Undertakers' Apparatus	20
4.7	Overall Construction Approach and Philosophy	21
4.8	Environmental Mitigation at Structures	22
5	**STRUCTURAL FORM – OTHER FACTORS AFFECTING CHOICE**	**24**
5.1	Loading	24
5.2	Durability	26
5.3	Ground Conditions	27
5.4	Span Arrangements, Choice of Materials and Safe by Design	27
5.5	Comparative Construction Costs	29
5.6	Comparative Whole Life costs	29
5.7	Sustainability	30
6	**STRUCTURES OPTIONS**	**31**
6.1	Introduction	31
6.2	Watercourse Crossings - Minor	33
6.3	Watercourse Crossings – Afon Rhyd and Afon Cadnant	36
6.4	Large Box Underbridges	39
6.5	Overbridges	63
6.6	S108 Welsh Highland Railway (Pont Cefnwerthyd Bridge - WG Asset Number A487 591)	119
6.7	S106 Afon Gwyrfai Viaduct (WG Asset Number A487 581) – Conforming Design	129
6.8	S106 Afon Gwyrfai Viaduct (WG Asset Number A487 581) – VE Design	152

6.9	S112 River Seiont Viaduct	153
6.10	Ancillary Structures and Strengthened Slopes	190
7	**SUMMARY AND RECOMMENDATIONS**	**191**
APPENDIX A – WHR LOAD & STRUCTURE GAUGE		**195**
APPENDIX B – OUTLINE FOUNDATION SCHEDULE		**197**
APPENDIX C – COMPARATIVE CAPITAL AND WHOLE LIFE COSTS		**203**
APPENDIX D – GENERAL ARRANGEMENT DRAWINGS FOR RECOMMENDED SOLUTIONS		**221**

1 EXECUTIVE SUMMARY

1.1 Background and Context

1.1.1 The existing A487 is a single carriageway road in a rural location. The route is classified and maintained as a strategic trunk road by the North and Mid Wales Trunk Road Agency, on behalf of the Welsh Government, and experiences significant traffic congestion.

1.1.2 Congestion experienced in Caernarfon arises from increasing traffic volumes on the A487. This has resulted in community severance and reduced quality of life in settlements and dwellings adjacent to the A487, which are adversely affected by the high volumes of traffic passing through them.

1.1.3 In addition, the lack of high quality connectivity southwards on the A487 from Bangor and the A55 is seen to be hindering economic development in the region. The development of the Menai Hub provides an opportunity to strengthen and restructure the economy in North West Wales. However its successful implementation and dispersal of benefits is reliant on good quality transport links.

1.1.4 Extensive work has been undertaken to identify traffic problems in and around Caernarfon, Gwynedd, dating back to the early 1990's when a study to investigate possible bypass routes was commissioned by the Welsh Office to increase network capacity.

1.1.5 Following the investigation of route options and two public consultations, a Preferred Route (Purple Route) was recommended. This Preferred Route was announced by the Minister for Local Government and Communities in July 2012. As a result of budgetary pressures the Minister for Economy, Science and Transport decided to review the options and in May 2013 adopted the Yellow Option as the Preferred Route.

1.1.6 The Yellow Option has been designated the Preferred route and the line has been protected from future development encroachment using a TR111. This will allow the further development of the scheme to improve the A487 around Caernarfon and Bontnewydd, whilst providing connections to the trunk road network east-west and north-south in line with 'One Wales: Connecting the Nation', 'The Wales Transport Strategy' and the 'National Transport Plan'.

1.1.7 In 2014, Welsh Government appointed Employer's Agent E C Harris and design consultant Ramboll to prepare the A487 Caernarfon to Bontnewydd Bypass scheme for ECI procurement, and in December 2014 a Balfour Beatty/Jones Brothers Joint Venture (JV) won the commission with designers WSP|Parsons Brinckerhoff and TACP.

1.2 The Scheme

1.2.1 The A487 Caernarfon to Bontnewydd Scheme involves the delivery of a primarily rural new highway, which is to be constructed off-line through a gently graded open landscape, largely characterised by scattered farms with associated field patterns and hedge boundaries. There are two significant river crossings over the Afon Gwyrfai and the Afon Seiont. The rural landscape through which the Scheme passes is characterised by extensive views inland to Snowdonia and to the Menai Straits and to Anglesey. The area also contains a number of designated sites of international,

national and local biodiversity value. Of particular relevance are the Glynllifon Bats Special Area of Conservation (SAC) and the Afon Gwyrfai SAC both of which have implications for structure design and provision.

1.3 This Report

1.3.1 This Structures Design Options Report shall be read in conjunction with the over-arching *Design Options Report Highways* reference 3513874-PB-XX-XX-RP-J-00006. The over-arching *Design Options Report Highways* considers the scheme as a whole within its geographical setting, summarises the status of the scheme at Key Stage 2, and reports on how the scheme has developed during the tender for, and early part of, Key Stage 3 as a result of further design development. The work undertaken to determine the optimum overall highway solution, with associated crossing points in relation to physical constraints, is covered in the over-arching *Design Options Report Highways* from which the need for particular structures to support the optimum solution is defined at a high level (i.e. the resulting need is simply defined as an overbridge, underbridge, viaduct, etc).

1.3.2 Once the need for a structure has been defined, then there are a variety of structural solutions which could be developed to meet the particular need. These will typically involve consideration of different structural forms and structural materials.

1.3.3 This *Structures Design Options Report* therefore sets out a synopsis of the scheme-wide issues and context applicable to the development of structural options, and provides an overview of other factors affecting the choice of structural form, before going on to examine the range of options which could provide an appropriate solution in order to meet the defined need.

For each of the structural options, consideration has typically been given to:

- Outline construction methodology.
- A review of the proposed structural form against the Context for Structures and Other Factors Affecting Choice identified in Sections 4 and 5 of this report below, respectively.
- Comparative capital cost for construction.
- Comparative whole life cost with due regard to maintenance requirements during the working life of the structure.

1.3.4 Consideration of the three pillars of sustainability – namely economic, social and environmental impacts – has been given at both the high level highway option appraisal which defined the need for certain structures in certain locations to support the holistic scheme proposals, and in turn at a local level in determining appropriate structural options. Such consideration is presented in the over-arching *Design Options Report Highways* reference 3513874-PB-XX-XX-RP-J-00006, as well as being inter-woven into the text throughout this report, and hence is embodied in the recommendations made for proposed structural solutions for each of the structures along the scheme.

1.3.5 For structural proposals, the typical approach taken has been to consider groups of structures where appropriate, to develop options for a generic solution representative of the group, and to then apply the outcome of this work to the specific details of the individual structures within the group. Where a structure is unique, likely solutions appropriate to the numerous constraints have been developed for comparative purposes, and again the outcome of this work has then been applied and refined to

meet the specific details and constraints at the structure location which have crystallised out of the design process following receipt of topographical survey information, ground investigation information, flood modelling outputs, stakeholder feedback, freezing of the highway alignment, etc.

1.3.6 As a result of such consideration, a recommendation as to the structural form to be adopted for further design development through the remainder of Key Stage 3 and then on to Key Stage 6 is made.

1.4 Summary and Recommendations for Structures along the Scheme

1.4.1 The table below contains a summary of the structures to be provided as part of the scheme, and contains recommendations as to the form and materials to be developed through the next stages.

Structure	WG Structure Name	WG Asset No.	Type	Recommended Structural Form and Materials
S101	Ty Hên Culvert	A487 550 C68	1.8m Pipe	1.8m diameter proprietary concrete pipe.
S101A	Pont Parc Underpass	A487 561	Box Underbridge	In-situ reinforced concrete box structure with either in-situ reinforced concrete roof slab or a roof slab incorporating pre-cast concrete beams. 7.2m wide x 5.8m high nominal internal opening.
S102	Afon Rhyd Culvert	A487 565	Box Culvert	In-situ or proprietary pre-cast reinforced concrete box culvert. 3.2m wide x 1.8m high nominal internal opening.
S103	Ty'n Llan Overbridge	A487 571	Overbridge	3 span pre-cast pre-stressed concrete beam superstructure made fully integral with 2 no. reinforced concrete piers and 2 no. bankseat abutments.
S104	Geufron Culvert	A487 571 C80	1.8m Pipe	1.8m diameter proprietary concrete pipe.
S105	Dinas Accommodation Underpass	A487 575	Box Underbridge	In-situ reinforced concrete box structure with either in-situ reinforced concrete roof slab or a roof slab incorporating pre-cast concrete beams. 4.5m wide x 4.65m high nominal internal opening.
S106	Afon Gwyrfai Viaduct	A487 581	Viaduct	8 span steel concrete composite multi-beam superstructure continuous over reinforced concrete leaf piers, with reinforced concrete cantilever abutments.
S107	Pont Llydiart Gwyn	A487 585	Box Underbridge	In-situ reinforced concrete box structure with either in-situ reinforced concrete roof slab or a roof slab incorporating pre-cast concrete beams. 7.2m wide x 5.8m high nominal internal opening.
S108	Pont Cefnwerthyd	A487 591	Underbridge	Single span pre-cast pre-stressed concrete beam solid infill superstructure cast fully integral with deck end bankseats, supported on reinforced soil substructures incorporating vertical pre-cast concrete fascia panels.
S109	Pont Ceriw NMU Overbridge	A487 601	Overbridge	Single span pre-cast pre-stressed concrete beam solid infill superstructure cast fully integral with deck end bankseats, supported on reinforced soil substructures incorporating vertical

Structure	WG Structure Name	WG Asset No.	Type	Recommended Structural Form and Materials
				pre-cast concrete fascia panels.
S109A	Pen Y Bryn Culvert 3	A487 601 C01	1.8m Pipe	1.8m diameter proprietary concrete pipe.
S110A	Pen Y Bryn Culvert 2	A487601 C58	1.8m Pipe	1.8m diameter proprietary concrete pipe.
S110	Pen y Bryn Culvert 1	A487 601 C73	1.8m Pipe	1.8m diameter proprietary concrete pipe.
S111	Pont Bryn Mafon	A487 611	Box Underbridge	In-situ reinforced concrete box structure with either in-situ reinforced concrete roof slab or a roof slab incorporating pre-cast concrete beams. 7.2m wide x 5.8m nominal internal opening.
S111A	Bryn Mafon Culvert 1	A487 611 C08	1.8m Pipe	1.8m diameter proprietary concrete pipe.
S111B	Bryn Mafon Culvert 2	A487 611 C09	1.5m Pipe	1.5m diameter proprietary concrete pipe.
S112	Pont Afon Seiont Newydd	A487 621	Viaduct	6 span steel concrete composite ladder deck superstructure continuous over reinforced concrete pier columns to each edge girder, with reinforced concrete cantilever abutments. Single span pre-cast pre-stressed concrete beam solid infill superstructure cast fully integral with reinforced concrete cantilever abutments over A4085.
S112A	Bodrual Culvert 2	A487 621 C61	1.5m Pipe	1.5m diameter proprietary concrete pipe.
S112B	Bodrual Culvert 1	A487 621 C59	1.5m Pipe	1.5m diameter proprietary concrete pipe.
S113A	FP 36	A487 625	Box Underbridge	Proprietary pre-cast reinforced concrete box structure. 3.0m wide x 2.6m nominal internal opening.
S114	Afon Cadnant Cattle Creep / Culvert	A487 631	Box Underbridge	Proprietary pre-cast reinforced concrete box structure. 3.4m wide x 3.4m nominal internal opening.
S114A	Lon Glai Culvert	A487 631 C08	1.8m Pipe	1.8m diameter proprietary concrete pipe.
S115	Bethel Road Overbridge	A487 635	Overbridge	Single span pre-cast pre-stressed concrete beam and slab superstructure cast fully integral with deck end bankseats, supported on reinforced soil substructures incorporating vertical pre-cast concrete fascia panels.
S115A	Bethel Road Culvert 1	A487 635 C01	1.8m Pipe	1.8m diameter proprietary concrete pipe.

Structure	WG Structure Name	WG Asset No.	Type	Recommended Structural Form and Materials
S115B	Bethel Road Culvert 2	A487 635 C03	1.8m Pipe	1.8m diameter proprietary concrete pipe.
ADS	TBC	TBC	Sign posts & foundations	Proprietary posts and in-situ concrete gravity foundations.

2 THE PROJECT

2.1 Context

2.1.1 Caernarfon is located on the Menai Straits which separates mainland Wales from Anglesey and is in the Welsh-speaking heartland of North Wales. Caernarfon has a population of just under 10,000. Caernarfon has experienced considerable growth, expanding beyond the medieval town walls and developing as the administrative centre of Gwynedd.

2.1.2 It is located on a coastal plain adjacent to a plateau to the banks of the Afon Seiont. It sits approximately 60 miles from the English border, 9 miles from Bangor to the north and 70 miles from Aberystwyth to the south.

2.1.3 The existing A487 is a single carriageway road in a rural location. The route is classified and maintained as a strategic trunk road by the North and Mid Wales Trunk Road Agency, on behalf of the Welsh Government, and experiences significant traffic congestion.

2.1.4 Congestion experienced in Caernarfon arises from increasing traffic volumes on the A487. This has resulted in community severance and reduced quality of life in settlements and dwellings adjacent to the A487, which are adversely affected by the high volumes of traffic passing through them.

2.1.5 To avoid the congested A487, adjacent substandard routes are being used as 'rat-runs' at inappropriate speeds. This, in particular, includes the Caeathro / Pont Rug road known locally as the 'unofficial bypass'.

2.1.6 The lack of high quality connectivity southwards on the A487 from Bangor and the A55 is seen to be hindering economic development in the region. The development of the Menai Hub provides an opportunity to strengthen and restructure the economy in North West Wales. However its successful implementation and dispersal of benefits is reliant on good quality transport links.

2.2 Background

2.2.1 Extensive work has been undertaken to identify traffic problems in and around Caernarfon, Gwynedd, dating back to the early 1990's when a study to investigate possible bypass routes was commissioned by the Welsh Office to increase network capacity.

2.2.2 The Welsh Assembly Government's Trunk Road Forward Programme 2002, as updated by the 2004 Supplement and reprioritised in 2008, determines and describes how growing demands for road transport would be met in the short and medium term.

2.2.3 Arup was commissioned in February 2007 by the Welsh Assembly Government to undertake a WelTAG (Welsh Transport Planning and Appraisal Guidance) Planning Stage and Stage 1 Study to consider transport issues and options in the Llanwnda to Plas Menai corridor using the draft version of WelTAG (May 2007). Broad options were generated during this commission including a bypass route and a combination of online measures and were recommended for further testing under the WelTAG Stage 1 Appraisal process. A Stage 1 Appraisal continued from the work undertaken in the A487 WelTAG Study, Planning Stage and Stage 1 Report with the aim to identify a select group of transport options for further testing under the WelTAG Stage 2 Appraisal.

2.2.4 Parsons Brinckerhoff and TACP were formally appointed by the Transport & Strategic Regeneration (T&SR) of the Welsh Assembly Government (WAG) to undertake the WelTAG Stage 2 A487 Caernarfon to Bontnewydd Study in February 2009. The result of this study recommended the Purple, Yellow, Black, Orange, Red and Cyan Options for a bypass, having similar Appraisal Summary Table (AST) scores and impacts across the range of the criteria in WelTAG, should all be presented as feasible solutions to the public as part of the stakeholder consultation process.

2.2.5 The WelTAG Stage 2 study included an initial public consultation that took place between March and May 2010 and a supplementary public consultation that took place between November 2010 and January 2011. The public consultations demonstrated clearly that the public accepted the need for improvements and that traffic conditions are the main cause of delayed journeys through Caernarfon and Bontnewydd.

2.2.6 Following the investigation of route options and two public consultations, a Preferred Route (Purple Route) was recommended. This Preferred Route was announced by the Minister for Local Government and Communities in July 2012. As a result of budgetary pressures the Minister for Economy, Science and Transport decided to review the options and in May 2013 adopted the Yellow Option as the Preferred Route.

2.2.7 The Yellow Option has been designated the Preferred Route and the line has been protected from future development encroachment using a TR111. This will allow the further development of the scheme to improve the A487 around Caernarfon and Bontnewydd, whilst providing connections to the trunk road network east-west and north-south in line with 'One Wales: Connecting the Nation', 'The Wales Transport Strategy' and the 'National Transport Plan'.

2.2.8 In 2014 Welsh Government appointed Employer's Agent E C Harris and design consultant Ramboll to prepare the A487 Caernarfon to Bontnewydd Bypass scheme for ECI procurement and in December 2014 a Balfour Beatty/Jones Brothers Joint Venture (JV) won the commission with designers WSP|Parsons Brinckerhoff and TACP.

2.3 The Scheme

2.3.1 The A487 Caernarfon to Bontnewydd Scheme involves the delivery of a primarily rural new highway, which is to be constructed off-line through a gently graded open landscape, largely characterised by scattered farms with associated field patterns and hedge boundaries. The new highway will connect from a new arm on the A499/A487 Goat roundabout to a new arm on the A487 Plas Menai roundabout junction.

2.3.2 The route shall be constructed to Wide Single 2+1 standards and achieve overtaking provisions as well as new laybys not less than those stated in the Key Stage 2 Technical Appraisal Report.

2.3.3 For the proposed alignment there are two significant river crossings over the Afon Gwyrfai and the Afon Seiont. The rural landscape through which the Scheme passes is characterised by extensive views inland to Snowdonia and to the Menai Straits and to Anglesey. The area also contains a number of designated sites of international, national and local biodiversity value. Of particular relevance are the Glynllifon Bats Special Area of Conservation (SAC) and the Afon Gwyrfai SAC both of which have implications for structure design and provision.

2.4 Project Objectives and Reason for Project

2.4.1 The Welsh Government's (WG) 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''.

2.4.2 The Deputy First Minister and Minister for Economy and Transport, Ieuan Wyn Jones AM, published Wales' Transport Strategy, One Wales: Connecting the Nation, in May 2008 which replaced the 2001 Transport Strategy for Wales. The Strategy outlines the Welsh Government's plans to create an integrated transport network that meets the challenge of environmental sustainability whilst facilitating transport links to all of Wales.

The Strategy has the following key aims:

- Cutting transport emissions.
- Joining up local transport.
- Improving access to key communities and settlements.
- Enhancing Wales' international connectivity.
- Promoting safety and security.

2.4.3 This also includes the Welsh Government's aim that by 2011 there will be a 3% cut in annual carbon-equivalent emissions in areas of devolved competencies.

2.4.4 The main aim of the Wales Transport Strategy was to create an integrated transport system as part of the One Wales commitments. The National Transport Plan is the mechanism by which the Welsh Government aims to integrate transport in Wales on a national scale. The draft national plan was published in July 2009 and sits alongside the regional transport plans in delivering the Transport Strategy.

2.4.5 The aims of the National Transport Plan are:

- To meet the demand for enhanced mobility to enable economic growth and to improve the quality of life we seek for the people of Wales.
- To put transport onto a more sustainable and less carbon-intensive path.
- To use transport funding more effectively in light of increasing pressures on public finances.

2.4.6 The specific Scheme Transport Planning Objectives (TPO) are found in the Contract Documents Volume 2 Section 1.4 and are listed below. These objectives and the scheme meet the aims of the National Transport Plan and overall strategy for Wales:

TPO1	Reduce journey time (between Llanwnda and Plas Menai) and improve journey time reliability to within +/- 3 minutes of the average journey time throughout the day.
TPO2	Reduce journey time (between Llanwnda and Caernarfon) and improve journey time reliability to within +/- 3 minutes of the average journey time throughout the day.
TPO3	Reduce the number of vehicles passing through residential communities;

	including Llanwnda, Dinas, Bontnewydd and Caernarfon.
TPO4	Scheme to contribute to the Welsh Government casualty reduction targets: • 40% reduction by 2020; • 255 reduction in motorcyclists by 2020; and • 40% reduction in the number of young children killed or seriously injured by 2020.
TPO5	Improve network resilience – Increase the amount and/or capacity of alternative routes to improve the resilience of the network.

3 PURPOSE OF THIS REPORT

3.1 Introduction

3.1.1 This Structures Design Options Report shall be read in conjunction with the over-arching *Design Options Report Highways* reference 3513874-PB-XX-XX-RP-J-00006.

3.1.2 It should be noted that design development during the early part of Key Stage 3 is characterised by many parallel activities, and the production of an over-arching Design Options Report and a separate Structures Design Option Report is a reporting convenience which belies the complex and iterative interdependency between highway and structural solutions.

3.1.3 The over-arching *Design Options Report Highways* considers the scheme as a whole within its geographical setting, summarises the status of the scheme at Key Stage 2, and reports on how the scheme has developed during the tender for, and early part of, Key Stage 3 as a result of further design development.

3.1.4 The need to provide any particular structure, and whether that particular structure is an overbridge, an underbridge, a culvert, a cattle creep, etc., is defined through the holistic consideration of the crossing problem to be solved, set in the context of the strategic objectives for the whole scheme, and the global and local impacts on the numerous constraints and affected stakeholders. Different highway alignment options, for example, will result in different structural scheme content in order to provide acceptable solutions. Similarly, even for a single highway alignment option, there will be several different structural options to address potential severance along the scheme, the optimum solution for which can only be determined from holistic consideration and appropriate assessment against the numerous constraints, coupled with engagement with the affected stakeholders. Design is an iterative process, and as the numerous highway options have been developed during the early part of Key Stage 3, the Structures team has supported this development through the provision of structural advice, particularly in relation to likely construction forms and construction depths for structures.

3.1.5 The work undertaken to determine the optimum overall highway solution, with associated crossing points in relation to physical constraints, is covered in the over-arching *Design Options Report Highways* reference 3513874-PB-XX-XX-RP-J-00006 from which the need for particular structures to support the optimum solution is defined at a high level (i.e. the resulting need is simply defined as an overbridge, underbridge, viaduct, etc).

3.1.6 Once the need for a structure has been defined, then there are a variety of structural solutions which could be developed to meet the particular need. These will typically involve consideration of different structural forms and structural materials.

3.1.7 This *Structures Design Options Report* therefore sets out a synopsis of the scheme-wide issues and context applicable to the development of structural options, and provides an overview of other factors affecting the choice of structural form, before going on to examine the range of options which could provide an appropriate solution in order to meet the defined need.

For each of the structural options, consideration has typically been given to:

- Outline construction methodology.

- A review of the proposed structural form against the Context for Structures and Other Factors Affecting Choice identified in Sections 4 and 5 of this report below, respectively.
- Comparative capital cost for construction.
- Comparative whole life cost with due regard to maintenance requirements during the working life of the structure.

3.1.8 With numerous highway design iterations for both the A487 main line and side roads, ground investigation works, topographical survey works, flood modelling, iterations for earthworks to achieve a cut fill balance, Public Information Exhibitions and other stakeholder liaison, all progressing in parallel during the early part of Key Stage 3, and with any recommendations informing the scheme structures content (even as fundamental as overbridge versus underbridge) then coming near the end of the programmed period for production of the Design Options Reports, the challenges of providing a number of options for each particular bridge location for an evolving design in a restricted programme have been considerable.

3.1.9 The typical approach taken therefore, has been to consider groups of structures where appropriate, to develop options for a generic solution representative of the group, and to then apply the outcome of this work to the specific details of the individual structures within the group. Where a structure is unique, likely solutions appropriate to the numerous constraints have been developed for comparative purposes, and again the outcome of this work has then been applied and refined to meet the specific details and constraints at the structure location which have crystallised out of the design process following receipt of topographical survey information, ground investigation information, flood modelling outputs, stakeholder feedback, freezing of the highway alignment, etc.

3.1.10 As a result of such consideration, a recommendation as to the structural form to be adopted for further design development through the remainder of Key Stage 3 and then on to Key Stage 6 is made.

3.2 Location Plan and Structures

3.2.1 The A487 Caernarfon to Bontnewydd Bypass preferred route and structure locations are indicated on the plan on the following page.

3.2.2 The table below provides a summary of the structures geographically along the scheme to which the content of this Structures Design Options Report relates, i.e. those falling within the Scope of *BD2/12 Technical Approval of Highway Structures* Clause 3.3.

Structure	Type	WG Structure Name	WG Asset No.
S101	1.8m Pipe	Ty Hên Culvert	A487 550 C68
S101A	Box Underbridge	Pont Parc Underpass	A487 561
S102	Box Culvert	Afon Rhyd Culvert	A487 565
S103	Overbridge	Ty'n Llan Overbridge	A487 571
S104	1.8m Pipe	Geufron Culvert	A487 571 C80
S105	Box Underbridge	Dinas Accommodation Underpass	A487 575
S106	Viaduct	Afon Gwyrfai Viaduct	A487 581
S107	Box Underbridge	Pont Llydiart Gwyn	A487 585
S108	Underbridge	Pont Cefnwerthyd	A487 591
S109	Overbridge	Pont Ceriw NMU Overbridge	A487 601
S109A	1.8m Pipe	Pen Y Bryn Culvert 3	A487 601 C01
S110A	1.8m Pipe	Pen Y Bryn Culvert 2	A487601 C58
S110	1.8m Pipe	Pen y Bryn Culvert 1	A487 601 C73
S111	Box Underbridge	Pont Bryn Mafon	A487 611
S111A	1.8m Pipe	Bryn Mafon Culvert 1	A487 611 C08
S111B	1.5m Pipe	Bryn Mafon Culvert 2	A487 611 C09
S112	Viaduct	Pont Afon Seiont Newydd	A487 621
S112A	1.5m Pipe	Bodrual Culvert 2	A487 621 C61
S112B	1.5m Pipe	Bodrual Culvert 1	A487 621 C59
S113A	Box Underbridge	FP 36	A487 625
S114	Box Culvert	Afon Cadnant Cattle Creep / Culvert	A487 631
S114A	1.8m Pipe	Lon Glai Culvert	A487 631 C08
S115	Overbridge	Bethel Road Overbridge	A487 635
S115A	1.8m Pipe	Bethel Road Culvert 1	A487 635 C01
S115B	1.8m Pipe	Bethel Road Culvert 2	A487 635 C03
ADS	Sign posts & foundations	TBC	TBC

4 CONTEXT FOR STRUCTURES

4.1 Introduction

4.1.1 The structures to be provided along the length of the scheme cannot be considered in isolation. They clearly need to be developed in the Scheme context, i.e. the delivery of a primarily rural new highway, which is to be constructed off-line through a gently graded open landscape, largely characterised by scattered farms with associated field patterns and hedge boundaries, with two relatively significant river crossings. Obviously, the structures are symbiotic with the highway alignment, but more than this, they need to integrate into the rural setting, and complement the desire to minimise impacts on the local and travelling communities, in order to deliver a buildable and sustainable holistic scheme.

4.1.2 Cognisance needs to be taken of the many scheme-wide issues and interfaces in order to determine appropriate structural forms during option development. Scheme-wide issues applicable to the development of structural options are described in this section of the report. Other issues or interfaces specific to either individual structures, or groups of structures, are described in more detail in Section 6 below.

4.2 Key Stage 2 Report

4.2.1 At Key Stage 2, consideration was given to structures to determine the likely number required for each of the route options, and to present reasonable solutions in terms of span arrangements and materials for construction, primarily in order to inform the cost estimates and other sustainability impacts for the various route options. The findings were presented in the report entitled *Assessment of Options for New Structures – Volume 1 Report Number HHC91381A/19/1 March 2012*.

4.2.2 The combination of structures along the specific route sections which form the current Key Stage 3 basis of the A487 Caernarfon to Bontnewydd bypass were broadly characterised at Key Stage 2 by:

- A series of reinforced concrete pipe and box culverts to watercourses below the A487 main line.
- A series of reinforced concrete box underbridges to side road and accommodation access crossings below the A487 main line.
- A series of steel concrete composite 3 span overbridges to side road and accommodation access crossings above the A487 main line.
- A steel concrete composite 3 span underbridge supporting the A487 crossing of the Welsh Highland Railway (WHR).
- Multi-span steel concrete composite parallel multi-beam viaduct crossings of the Afon Gwyrfai and Afon Seiont.

4.3 Highway Alignment and Earthworks Balance

4.3.1 The output of the Key Stage 2 works formed the basis of the Illustrative Design provided by Welsh Government to Key Stage 3 Tenderers for the Scheme.

4.3.2 During the Key Stage 3 Tender period, the significant sustainability and capital works cost benefits of achieving an earthworks balance, whilst minimising the quantity of material to be moved between cutting and embankment areas, were quickly realised. As well as delivering a lower capital works cost for the scheme, the reduction in earth moving activities offers significant social and environmental benefits, for example

through a reduced scheme footprint, greater areas returned to agriculture, reduced construction traffic in the vicinity or through local communities, reduced construction noise, etc.

4.3.3 Design work was therefore undertaken during the Tender period to refine the highway alignment, particularly the vertical alignment, and side slope earthworks profiles in order to provide an optimal earthworks solution. As a result of this work, certain overbridges identified as such in the Key Stage 2 Illustrative Design became underbridges, and vice versa. Clearly, several of the structures along the route constrain the main line vertical alignment by virtue of the need to achieve an appropriate headroom, ground or freeboard clearance either above or below.

4.3.4 In addition, consideration was given to the arrangement of side roads in relation to the main line at the northern end of the scheme, in the vicinity of Bethel Road. This allowed some rationalisation of structures to be provided, and their removal from the Key Stage 2 Illustrative Design Scheme was reflected in the Target Cost for the scheme offered at Tender.

4.3.5 The significant opportunities and benefits associated with all of the above, as identified at Tender, have underpinned the development of the scheme both technically and with stakeholders through Key Stage 3 to date.

4.3.6 At the beginning of Key Stage 3, information relating to existing ground levels and existing ground conditions which underpinned the Tender design was scant, and there was clearly a degree of risk in achieving an earthworks balance associated with the assumptions. However, as Key Stage 3 has progressed, a topographical survey, watercourse channel survey and a ground investigation have all been undertaken, the results of which have gradually fed into the refinement of the highway design and side slope earthworks profiles to allow the aspirational earthworks balance to be achieved in principle.

4.3.7 Further detailed description of the highway alignment options and earthworks development are contained in the over-arching *Design Options Report Highways* reference 3513874-PB-XX-XX-RP-J-00006.

4.4 Aesthetics and Landscape Effects

4.4.1 The landscape context for the scheme is primarily rural. The landscape design objective for bridge structures over the main line is therefore to keep them as open as possible in main line cut situations, to allow views through the structures, and to facilitate a continuity of landscape treatment along the scheme corridor. Splayed and sloping wing walls will be incorporated in order to maximise the available area for mitigation planting. As well as providing visual screening and landscape integration this approach also maintains habitat connectivity with the associated biodiversity benefits.

4.4.2 Further aesthetic benefits derive from the creation of a family of structures, using a similar palette of materials, forms and finishes for groups of similar structures. Acknowledging the palette of finishes typically provided on structures on other similar schemes along the A487 in the locality, the proposed finishes broadly comprise:

- Plain concrete to small areas of exposed surfaces, such as headwalls and wingwalls to small culvert structures;
- Plain, or virtually plain, concrete to large exposed surfaces viewed obliquely and typically shaded – for example, the internal walls of box-type structures, pier and abutment elevations;

- Feature grooved concrete finish to large exposed concrete surfaces, such as wingwalls to highway bridges – such finishes allow the inclusion of through-ties in formwork shutters to achieve a more sustainable solution through the provision of cheaper construction typically requiring the use of less materials;
- Vertical plain concrete facing panels to reinforced soil substructures;
- Coloured protective paint system to structural steel elements to bridge structures;
- Repeated details allowing for re-use of formwork, providing a more sustainable solution through use of less materials and cost savings.

4.4.3 In addition, similar details and finishes along both this scheme and others in the locality lead to economies in planned maintenance activities which safeguard the integrity of the structures for use by future generations.

4.5 Highway Interfaces

4.5.1 Alignment and Headroom

4.5.1.1 All structures above the public highway are to provide a minimum of 5.3m headroom clearance above the carriageway and verge surfaces within the "Structure Free Zone" defined in *TD27/05 Cross-Sections and Headrooms*.

4.5.1.2 For lightweight footbridge/NMU (non-motorised user) structures proposed for the scheme, a headroom of 5.7m will be provided. No proposed lightweight gantry structures are proposed for the scheme.

4.5.1.3 Note that whilst Welsh Government has issued an instruction under PMI 001 of 22 April 2015 entitled, "Assess Impact of a change to Abnormal Vehicle Loading" for some study work into the effects of abnormal vehicle movements along the A487 Caernarfon to Bontnewydd bypass (see Section 5 below), this instruction specifically states, "*The study should not consider the need to make any changes to the contractor's proposals to accommodate any increased height of any abnormal vehicles."*

4.5.1.4 For farm accommodation underpasses and overbridges which are to accommodate the passage of machinery, reference has been made to Clause 5.11.3 of *TD27/05 Cross-Sections and Headrooms* and the documents cited therein *(Provision of Farm Crossings* published jointly by the Department for Transport and National Farmers Union, and the *Report of the Study Group on Dimensions of Agricultural Bridges and Underpasses* published by MAFF and the Department for Transport). For such underpasses, recommendations are to provide a minimum of 4.25m headroom clearance above the carriageway surface, with a width of 4.5m between abutment faces in order to accommodate the passage of agricultural machinery in "transport" mode. All farm accommodation overbridges are to typically provide a minimum of 4.5m width between parapet faces, again to accommodate the passage of agricultural machinery in "transport" mode.

4.5.1.5 Proposed dimensions for such structures have been agreed following consultation with local land owners affected by the scheme and are appropriate to the scale and methods of farming in the area. Evidence of relevant consultation in relation to structures needing to accommodate farm machinery access is to be provided within AIP documentation following acceptance of any recommendations made within the Design Options Reports.

4.5.1.6 Structures passing over the heritage Welsh Highland Railway (WHR) tracks are to provide a minimum of 3.65m headroom, and 2.0m lateral clearance to substructure

faces, based on the Ffestiniog Railway Company Civil Engineering Department Porthmadog 'Load & Structure Gauge (Welsh Highland Section)' gauge dimensions set out on Drawing PW30A dated 10/02/06 and supplied by WHR representatives on 10 March 2015, contained in Appendix A.

4.5.1.7 Where reasonably practicable, 5.7m headroom is to be provided to structures above public roads for which the economic benefits and lower risk of not having to design for the effects of superstructure collision can be realised.

4.5.1.8 In consideration of all headrooms, an appropriate allowance has been made for the effects of settlement, deflection and sag curve compensation in determining the feasibility of the options presented for structures in this report.

4.5.1.9 The geometry of structures has been determined in order to accommodate the design requirements of the highway vertical and horizontal alignment design, particularly in relation to forward visibility, without recourse to invoking Departures from Standards along the main line.

4.5.2 Drainage

4.5.2.1 The interface between the scheme drainage network and structures is summarised below:

Main line

- At underbridges and culvert crossings where insufficient cover exists to allow mainline carrier drainage systems through and over the interface, the carrier system will be terminated and routed to an attenuation pond.

- At overbridges, swale runs beneath the structures will be temporarily terminated up-grade, with the drainage continued through in a traditional carrier drain. Dependent on the final choice of potential bridge pier/abutment configurations, the introduction of lateral offsets to the carrier system to 'dog-leg' around pier foundations may be required.

Side roads

- Side road carrier drainage, where present, is interrupted at overbridges or underbridges.
- The drainage of side roads supported on overbridges is either via a straight grade long fall to one end of the bridge deck, or via a highway vertical alignment crest curve falling to both ends of the deck, all facilitated by solid precast kerbs along the bridge deck itself. From the deck ends, drainage is discharged to the side road drainage network where this is present. Rear wall drainage to end supports is to be discharged into the main line drainage network below.
- The drainage of side roads accommodated within underbridges is via a straight grade long fall to one end of the underbridge. Solid precast kerbs provided to the back of the carriageway through the structure will accommodate any surface water passing through, directing it to gullies or channels located at the lower end. Where a positive drainage system exists for the side road, drainage from the structure ends and rear wall substructure drainage will be appropriately connected into this. Low points contained within underbridge structure will be avoided.

Viaducts

- For viaduct structures, the superstructure is to be superelevated in cross section such that the top surface of the deck will follow the super-elevation of the highway alignment (a single crossfall is proposed). Bridge-deck combined kerb drainage units are therefore to be provided to one side of the deck only. A long fall will be provided to viaduct structures to facilitate drainage to one end of the deck. Preliminary hydraulic analysis indicates that both of the proposed viaduct decks can be drained without the use of intermediate outfall points, thus reducing the requirement for the provision of external carrier pipework attached to the bridge superstructure. Low points in the vertical alignment within the length of the viaducts will be avoided.

4.5.2.2 The development of structures options is in line with the drainage interface philosophy described above.

4.5.3 Street Furniture - signs and street lighting

4.5.3.1 Street furniture, such as signs and street lighting, is typically located away from structures. As such, no specific consideration has generally been given to making special provision to accommodate street furniture during the development of structural options for the scheme. Any specific considerations are listed in Section 6 below.

4.5.4 Surfacing, kerbs and Local Authority Requirements

4.5.4.1 In determining overall construction depths at bridge structures, it is assumed that all bridge decks will be provided with a minimum of 120mm of bituminous surfacing above a proprietary bridge deck waterproofing system (in accordance with *IAN96/07 Revision 1 Guidance On Implementing Results Of Research On Bridge Deck Waterproofing*).

4.5.4.2 It is assumed that kerbs to main line structures will comprise 75mm upstand splay kerb units, in accordance with *TD27/05 Cross-Sections and Headrooms* Clause 5.7.4. Kerbs to side roads, passing over overbridge structures or passing through underbridge structures, will comprise 125mm upstand half batter kerbs. Verges will typically fall towards the carriageway.

4.5.4.3 On side road structures, the demarcation between maintenance by Welsh Government and the relevant Local Authority would typically be top of waterproofing of the bridge deck, with the Local Authority providing maintenance of the finishes above the bridge deck waterproofing. The proposed carriageway and verge cross sections at side roads to be provided on overbridge or though underbridge structures have been discussed and agreed in principle with Gwynedd County Council at meetings during Key Stage 3 to date.

4.5.5 Vehicular Restraint Systems and Parapets, Pedestrian Restraint Systems

4.5.5.1 All bridge parapets are to be normal containment level N2, W2 working width. The requirements for lengths of Vehicle Restraint System (VRS) on the approaches to bridge structures will be determined from the RRRAP process. Typically, the approach VRS is to be connected to the ends of bridge parapets.

4.5.5.2 Account has been taken of the required VRS working width at connections to bridge parapets in determining earthworks profiles and hence the required land-take on bridge approaches.

4.5.5.3 All parapets meet the minimum required heights derived from *TD19/06 Requirement for Road Restraint System*, Clause 4.23. Proposed parapets are typically 1000mm high, with full height mesh infill, except where noted otherwise in Section 6 below.

4.5.5.4 Pedestrian restraint systems will be provided to the tops of all wing walls and head walls. At this stage, it is envisaged that the pedestrian restraint system will comprise a clamped tubular steel post and open rail system, mounted to the top of the concrete upstand at the face of the wall. This will preclude ready access in front of the restraint system along the concrete upstand.

4.6 Statutory Undertakers' Apparatus

4.6.1 Information received from consultation with Statutory Undertakers has identified the apparatus tabulated below will likely need to be accommodated within structures along the scheme.

4.6.2 Note that final consultation and relevant agreements with Statutory Undertakers is yet to be concluded, and so the apparatus provision proposals tabulated below will require formal confirmation in due course.

Structure	Statutory undertaker	Proposed Provision at Structure
S101A	Welsh Water	150mm* diameter main in 225mm diameter sleeve.
	BT	1 no. 100mm diameter duct.
S103	Welsh Water	150mm* diameter main in 225mm diameter sleeve.
	BT	1 no. 100mm diameter duct.
	Spare	1 no. 100mm diameter spare duct.
	Scottish Power	LV electricity in 1 no. 150 diameter duct.
S107	Welsh Water	300mm* diameter rising main in 450mm diameter sleeve.
	Welsh Water	150mm* diameter main in 225mm diameter sleeve.
	BT	1 no. 100mm diameter duct.
	Spare	1 no. 100mm diameter spare duct.
	Scottish Power	33kV electricity in 3 no. 150mm diameter ducts.
	Scottish Power	LV electricity in 1 no. 150mm diameter duct.

Structure	Statutory undertaker	Proposed Provision at Structure
S110A	BT	3 No. 100mm diameter ducts (west verge) and 1 No. 100mm diameter ducts (east verge) within highway construction above.
S111	BT	1 No. 100mm diameter duct.
	Spare	1 No. 100mm diameter spare duct.
S112A	BT	4 no. 100mm diameter ducts, north verge, within highway construction.
S113A	Scottish Power	11kV electricity in 3 no. 150mm ducts.
	BT	1 no. 100mm diameter duct.
	Spare	1 no. 100mm spare duct.
S115	Welsh Water	150mm* diameter main in 225mm diameter sleeve.
	Fibrespeed	1 no. 114mmmm diameter duct.
	Scottish Power	11kV electricity in 3 no. 150mm diameter ducts.
		*Assumed diameters in absence of definitive information.

4.6.3 In addition to the above provision for Statutory Undertakers' apparatus, all A487 main line underbridge structures will be required to accommodate 2 no. 150mm diameter communication ducts running along the proposed A487 main line.

4.7 Overall Construction Approach and Philosophy

4.7.1.1 One of the significant benefits of an ECI Scheme is the involvement of an experienced Contractor from the scheme outset, to assist in delivering best value through consideration of buildability and construction preferences.

4.7.1.2 The Key Stage 3 design has therefore been developed on the basis of the following overall construction approach:

- The scheme is to be constructed during Key Stage 6 over a period of nearly two years.
- The majority of the Earthworks are to be completed in the first season, which will go some way towards minimising the risk associated with adverse weather conditions.
- A haul road through the entire site will be provided and maintained largely within site boundary/trace throughout the construction period. This will reduce the amount of construction traffic on the local highway network, thereby reducing the adverse effects of construction work on the neighbouring communities (pollution, traffic, noise, etc.), and providing a more sustainable solution.

- Whilst the majority of the earthworks are taking place during the first season, the bridge structures will be designed and independently checked.
- Bridge structures will largely be constructed following the first earthworks season. This not only allows them to be designed and checked, but may also afford the opportunity to make greater use of spread foundations. Where structures are constructed on embankment fill, it allows for any immediate and consolidation settlement to have already occurred prior to completion of the foundations.
- The scheme has been developed assuming that elements are to be lifted from ground level using mobile cranes, where practicable. Such craneage is widely available, with a good range of lifting capacities, and affords quick, efficient and flexible construction.
- The speed of erection provides programme benefits, allowing just-in-time delivery of materials without recourse to sterilising lay-down areas for long periods of time. The ability to erect elements quickly also minimises disruption to the haul road, thereby reducing the impact on the surrounding highway network.
- Where appropriate, elements will be pre-fabricated or pre-cast. Prefabrication or pre-casting off site typically reduces work on site, much of which is often at height. It also provides factory control to construction operations.

4.8 Environmental Mitigation at Structures

4.8.1 Bats

4.8.1.1 The Scheme crosses an area characterised by significant bat activity. The approach to addressing the effects of the road on the bat populations is to treat the Scheme footprint as a “bat landscape”. Proposed mitigation measures for the potential impacts have been considered holistically for the scheme. Whilst a number of flight lines are broadly orientated parallel to the main line, there are nevertheless a number of flight lines which cross the main line.

4.8.1.2 A number of culvert-type structures have therefore been identified as being required in order to safeguard the existing bat flight lines which cross the line of the proposed scheme, although the majority of these are shared with other features such as water-courses, accommodation tracks, etc.

4.8.1.3 Bat activity is anticipated through all structures along the route, with the exception of the overbridges.

4.8.1.4 Appropriate landscape planting on the approaches to these structures within the footprint of the scheme is also proposed in order to connect the existing features which inform the flight lines to either side.

4.8.1.5 The combination of landscape planting and culvert alignment means that wingwall orientation is not critical to the proposed bat mitigation measures.

4.8.1.6 Note that bat boxes are to be avoided at structures as they typically severely restrict inspection and maintenance works.

4.8.2 Other protected species

4.8.2.1 Otters are known to be present to many of the watercourses along the scheme. As such, animal ledges are to be provided within certain culvert structures.

4.8.2.2 Where other protected species are known to potentially impact on the structural design solution, then this is covered in the discussion sections specific to those structures.

4.8.3 Culvert Bed Material

4.8.3.1 The Water Framework Directive places emphasis on water quality, biological value, and hydro-geomorphology.

4.8.3.2 In terms of hydro-geomorphology, it is proposed that culverts are vertically aligned such that the new culvert invert is located below the existing watercourse bed level. This will allow the culverts to develop a natural soft bed at they gradually silt up, which may be pushed out on occasion, equally naturally, under certain flood events.

4.8.4 Lighting

4.8.4.1 Partly in recognition of the adverse environmental impacts of new lighting for this predominantly rural scheme, there are no current proposals to light areas remote from the roundabouts.

4.8.4.2 No lighting provision is therefore to be made at structures, including underbridges.

4.8.5 Noise barriers and Screening

4.8.5.1 There are typically no requirements to provide environmental barriers along structures for the scheme. However, an environmental barrier provision may be required along the eastern edge of S112 Pont Afon Seiont Newydd viaduct (WG Asset No. A487 621) to provide noise mitigation and screening to the caravans in the caravan park alongside and below the viaduct. Any required provision will be developed as the scheme progresses through Key Stage 3.

4.8.6 Archaeology

4.8.6.1 Archaeological sites are not anticipated to affect the form or location of structures along the scheme. The proposed geophysics survey will allow for potential archaeological assets to be identified.

5 STRUCTURAL FORM – OTHER FACTORS AFFECTING CHOICE

5.1 Loading

5.1.1 Element sizes for structures design options are very much influenced by the live loading they are required to carry.

5.1.2 Loading requirements for Structures are defined in Interim Advice Note 124/14(W) *Use of Eurocodes for the Design of Highway Structures.*

5.1.3 Highway structures that carry traffic loads must be designed for BS EN 1991-2 *Eurocode 1: Actions on structures. Traffic loads on bridges,* load models LM1, LM2 and, if appropriate for pedestrians, LM4.

5.1.4 Highway structures that carry trunk road traffic must also be designed for all the SV models given in LM3 as defined in the UK National Annex to BS EN 1991-2.

5.1.5 The following table from IAN124/14(W) contains recommended SV model loading by class of road for the design of structures:

Table A.3 SV model vehicles for the design

Class of road carried by highway structure	SV models
Motorway and Trunk Roads (or principal road extensions of trunk routes)	SV80, SV 100, SV 196
Principal Roads (In Northern Ireland non trunk A roads) as agreed by TAA	SV80, SV100
Other Public Roads as agreed by TAA	SV 80

5.1.6 For the purposes of developing design options for structures, the following table of loading has been agreed in principle with Welsh Government Technical Approval Authority (TAA):

Structure Type	Structures	WG Ref	Name	LM3 SV Models*
A487 Trunk Road Underbridges	S101	A487 550 C68	Ty Hên Culvert	SV80, SV100, SV196
	S101A	A487 561	Pont Parc Underpass	
	S102	A487 565	Afon Rhyd Culvert	
	S104	A487 571 C80	Geufron Culvert	
	S105	A487 575	Dinas Accommodation Underpass	
	S106	A487 581	Afon Gwyrfai Viaduct	
	S107	A487 585	Pont Llydiart Gwyn	
	S108	A487 591	Pont Cefnwerthyd	
	S110	A487 601 C73	Pen y Bryn Culvert 1	

Structure Type	Structures	WG Ref	Name	LM3 SV Models*
	S111	A487 611	Pont Bryn Mafon	
	S111A	A487 611 C08	Bryn Mafon Culvert 1	
	S112	A487 621	Pont Afon Seiont Newydd	
	S112B	A487 621 C59	Bodrual Culvert 1	
	S113A	A487 625	FP 36	
	S114	A487 631	Afon Cadnant Cattle Creep / Culvert	
Principal Roads	S110A	A487601 C58	Pen Y Bryn Culvert 2	SV80, SV100
	S112A	A487 621 C61	Bodrual Culvert 2	
	S115	A487 635	Bethel Road Overbridge	
	S115A	A487 635 C01	Bethel Road Culvert 1	
Other Public Roads	S103	A487 571	Ty'n Llan Overbridge	SV80
	S109A	A487 601 C01	Pen Y Bryn Culvert 3	
	S111B	A487 611 C09	Bryn Mafon Culvert 2	
	S114A	A487 631 C08	Lon Glai Culvert	
	S115B	TBC	Bethel Road Culvert 2	
Accommodation, Occupation and NMU bridges	S109	A487 601	Pont Ceriw NMU Overbridge	None
				*In addition to LM1, LM2 and, if appropriate, LM4

5.1.7 At the TWG Structures meeting of 29 January 2015, Welsh Government drew attention to its ongoing strategic consideration of abnormal load movements along the A487 trunk road corridor with The Movement Along Welsh Routes (MAWR) Group. Welsh Government has since confirmed under PMI 001 of 22 April 2015 entitled, "Assess Impact of a change to Abnormal Vehicle Loading" that the following study is to be undertaken in parallel with the Key Stage 3 works:

"The Movement Along Welsh Routes (MAWR) Group have written to The Welsh Government (WG) recommending requirements for heavy loads on the proposed A487 Caernarfon Bontnewydd Bypass.

A comparison has been carried out between actual abnormal load vehicles proposed by MAWR and the theoretical vehicles which are set out in current design codes in order to determine which theoretical vehicles must be used in the design of structure on A487 Caernarfon to Bontnewydd Bypass.

All new structures on A487 Caernarfon to Bontnewydd Bypass are to be designed for the full range of SV vehicles as stipulated in the Employer's Works Information.

A further study should be carried out by the ECI Contractor to confirm the effect on Key Stage 6 costs of designing the structures and where applicable any other design element(s) for the following additional load cases:

SOV250 vehicle with no other traffic on the bridge deck

SOV350 vehicle with axle loads adjusted to give a GVW of 300Te and no other traffic on the bridge deck

The study should consist of a general assessment of the design elements that would be affected by the higher load cases and a detailed consideration of each structure is not required.

In carrying out this study advantage should be taken of the ability of the vehicle to travel along a specific line. The study should not consider the need to make any changes to the contractor's proposals to accommodate any increased height of any abnormal vehicles.

Subject to the results of the cost study to improve the Network Resilience in the long term, a decision will be made whether all new structures and where applicable any other design element(s) on A487 Caernarfon to Bontnewydd Bypass should be designed to carry higher vehicle loading with no co-existent live loading.

The study should be carried out in parallel with the current programme and scope of the Works Information, so as not to cause any delay to the Key Stage 3 programme."

5.1.8 For the purposes of this Structures Design Options Report, it has been assumed that the parallel study into the effects of changes to abnormal vehicle loading along the A487 Caernarfon to Bontnewydd bypass will not give rise to fundamental changes in design options, and that any changes arising out of any potential future requirement to accommodate the additional SOV250 and SOV350 vehicles as described and applied above would be to increase material quantities (for example additional reinforcement, additional pre-stressing or additional structural steel to flanges and webs) or to vary structural element depths where these can be readily accommodated without adversely impacting the co-ordinated global Key Stage 3 design study outcome.

5.2 Durability

5.2.1 Design options for structures need to take account of the requirements to design for durability in order to minimise future maintenance activities.

5.2.2 IAN124/14(W) advises that all bridges should be designed as continuous over intermediate supports unless special circumstances exist. All structure design options for multi-span bridges and viaducts on the scheme therefore propose continuity over all intermediate supports. Where bearings are proposed above intermediate supports, the design options assume provision is to be made for their replacement.

5.2.3 In addition, IAN124/14(W) advises that bridges with overall lengths not exceeding 60m and skews not exceeding 30˚ should be designed as integral bridges, with abutments connected directly to the bridge deck without movement joints and bearings for expansion or contraction of the deck. All structure design options for bridges within these geometric limits on the scheme therefore propose fully integral abutment end supports.

5.3 Ground Conditions

5.3.1 At the beginning of Key Stage 3, limited information was available on the underlying geology, and hence the ground conditions, of the scheme. British Geological Survey (BGS) mapping for the area had last been published in 1852 and has not been updated since. This mapping is lacking in detail and records no superficial deposits. During the Tender period, unpublished field mapping held by BGS was examined, and this provided a description of the superficial geology beneath the site. The ground conditions for the scheme are typified by glacial derived soils mantling the solid geology outside of the river valleys and stream lines. Within the river valleys and stream lines, overlying the glacial till or solid geology are alluvial soils and peats. The solid geology is recorded as comprising rocks from the Cambrian to the Carboniferous in age. Towards the northern end of the site, the solid geology is dominated by Rhyolite and Ignimbrite within the ridge above Plas Menai; elsewhere the solid geology is dominated by sedimentary rocks.

5.3.2 A ground investigation is currently being undertaken. This was designed and is being undertaken in accordance with the requirements of BS EN 1997-2 and HD 22/08. The results of the investigation are being returned to the designers in order to assess the foundation requirements for each structure. Based upon this draft information, the proposed foundations for each structure, together with limitations and appropriate caveats, are presented in Appendix B.

5.3.3 Further description of the ground conditions, based upon draft and incomplete ground investigation data, is contained within the over-arching *Design Options Report Highways* reference 3513874-PB-XX-XX-RP-J-00006.

5.4 Span Arrangements, Choice of Materials and Safe by Design

5.4.1 Span arrangements, choice of construction materials and safe by design are all inter-dependent, and therefore need to be considered holistically in determining the optimum form for a structure. Such holistic consideration needs to be given in the context of the particular problem to be solved, and so more detail in relation to each group of structures is presented in Section 6 below.

5.4.2 With regards to span arrangements and choice of materials, however, the following general points applicable to the whole scheme are noted:

- For any given span, construction with a different choice of materials will typically result in a different superstructure construction depth with associated impacts.
- For flat span superstructures, as a broad rule of thumb, the depth of economical superstructure construction is typically directly proportional to the span – so, longer spans typically necessitate proportionally greater superstructure construction depths with associated impacts.
- In addition, certain materials and forms will be appropriate to certain span ranges. However, as the span range increases, they will cease to become economic and hence a range of different materials and forms will become feasible.

- Three primary materials have typically been considered for bridge superstructures - reinforced concrete, pre-stressed concrete and steel concrete composite.
- For superstructures constructed from structural steelwork, it is typically possibly to split the beam lengths into smaller lengths and to then splice the steelwork elements together on site using bolted splices prior to erection, in order to reduce the steelwork lengths and weights for transportation.
- For superstructures constructed from pre-cast pre-stressed concrete beams, it is not possible to split the beams into smaller lengths and splice them on site.
- For superstructures constructed from pre-cast pre-stressed concrete beams, there are typically many more concrete beams required compared with steel beams.
- Prestressed concrete beams are typically more than twice the weight of steel beams for the same span. This may require greater craneage capacity to cope with the additional lift weights, although it is acknowledged that steel beams are often lifted in braced pairs to provide a safe and stable solution during construction.
- With regard to structural steelwork, it has been agreed with Welsh Government TAA that the use of weathering steel is unlikely to be acceptable given the relative proximity of the scheme to the coast. As such, it has not been considered further for use within the scheme. *BD7/01 Weathering Steel for Highway Structures* Clause 2.2 states that weathering steel should not be used in a marine environment where the structure would be affected by chloride, and that where this is unclear, the clause goes on to state that the level of chloride may be assessed according to ISO9223 and, where a salinity classification of S3 is found, then the use of weathering steel should be ruled out. This is echoed in an ICE Bridge Engineering Journal Paper which states that, in general, weathering steel should not be used within 2km of coastal waters unless the salinity levels are S2 or under as above. Testing for such salinity levels would need to be undertaken over a twelve month period, and there is a significant risk that such testing would demonstrate a high salinity which would rule out the use of weathering steel anyway. To rely on a positive outcome would therefore present an unacceptable risk to the project.
- Two primary materials have typically been considered for bridge substructures – in-situ reinforced concrete for all substructures or, where applicable, reinforced soil abutments and wingwalls with vertical hard panel facing.
- Reinforced soil substructures are now common-place on the trunk road network in England. In some very rare instances, it is understood from anecdotal evidence that reinforced soil substructures have proven to be somewhat problematic. Such problems are understood to originate from three primary sources, as outlined below:

    i Failure to manage settlement in the subgrade beneath the reinforced soil abutment leading to movements within the abutment/bankseat. This could potentially be an issue in the area of the Afon Gwyrfai as a result of alluvial sediments. Such settlements may be managed in a number of ways. Based upon the ground conditions encountered during the GI, these may include the use of vibro-stone columns to increase the density of granular materials and transfer loads to deeper less compressible strata. Alternatively a piled foundation could be adopted, either with a load carrying slab or a load transfer platform.

    ii Construction quality, through either failure of control of compaction or failure to control fill, both resulting in internal movements. This can be

mitigated by the use of strict control of the placement of fill, using an end product specification and requiring a high number of in-situ tests to ensure the specification is met. This process starts from the early stages of design by ensuring a full source evaluation investigation and associated reporting are undertaken to understand the engineering properties of the proposed fill. Based upon the results of this evaluation a detailed specification is then prepared, including the in-situ testing to confirm the required compaction is achieved. This specification also considers how verification of the testing is to be undertaken.

iii Design control, particularly in Design and Build schemes where the main Contractor has understood that the specialist reinforced soil supplier provides a full design service. Generally, the specialist suppliers only undertake the internal design without considering the global design. This risk is to be managed by the designer controlling the design process, ensure that third party designs are adequately checked and that the global stability issues are designed for and subject to the appropriate level of checking.

- With appropriate design, checking, specification and construction controls in place, reinforced soil can offer an economical and effective solution in some situations, and its use will therefore be considered for the scheme.

5.4.3 With regards to safe design, the following general points applicable to the whole scheme are noted:

- Structures are to be safe by design, from construction, through maintenance to eventual demolition.
- The principle of prevention to eliminate, reduce and control risks in accordance with the CDM Regulations 2015 has been adopted.
- The safe construction and maintenance of the individual elements of a structure varies greatly by span arrangement, material and form. The individual impacts associated with any design option choice need to be considered in relation to the overarching construction strategy and programme for the scheme.
- A brief summary overview of the construction methodology envisaged for each design option is presented in Section 6 below. However, it should be noted that this has been presented to outline key constraints and risks, and will be re-evaluated and varied as the chosen design evolves and progresses through the preliminary and detailed design stages.

5.5 Comparative Construction Costs

5.5.1 Where Structure design options are considered feasible in the context of the many scheme constraints, then a comparative capital works cost has been determined and has been included in Section 6 as appropriate. This cost has been compiled on a similar basis to the original Tender design costs in order to provide parity across options.

5.5.2 Further information regarding comparative construction costs are provided in Appendix C.

5.6 Comparative Whole Life costs

5.6.1 Where Structure design options are considered feasible in the context of the many scheme constraints, then a comparative whole life cost has also been determined and has been included in Section 6 as appropriate.

5.6.2 Further information regarding comparative whole life costs are provided in Appendix C.

5.7 Sustainability

5.7.1 The Scheme passes through a rural landscape characterised by extensive views inland to Snowdonia and to the Menai Straits and to Anglesey. The area also contains a number of designated sites of international, national and local biodiversity value. Of particular relevance is the Glynllifon Bats Special Area of Conservation (SAC) and the Afon Gwyrfai SAC both of which have implications for structure design and provision. In addition there are a number of protected species, in particular otters, which have implications for structure design.

5.7.2 Consideration of the three pillars of sustainability – namely economic, social and environmental impacts – has been given at both the high level highway option appraisal which defined the need for certain structures in certain locations to support the holistic scheme proposals, and in turn at a local level in determining appropriate structural options. Such consideration is presented in the over-arching *Design Options Report Highways* reference 3513874-PB-XX-XX-RP-J-00006, as well as being inter-woven into the text throughout this report, and hence is embodied in the recommendations made for proposed structural solutions for each of the structures along the scheme. An example of this is the effort to tie into side roads at the correct scale to mirror what is already present, rather than impose new design standards in isolation. This has been achieved through consultation with the local authority and results in structures being smaller with a subsequently more sustainable solution achieved through the reduced size and associated cost.

6 STRUCTURES OPTIONS

6.1 Introduction

6.1.1 Structures on the scheme, as defined by *BD2/12 Technical Approval of Highway Structures* Clause 3.3, have been grouped by form/function as listed in table below. Options considered are discussed by Structure Group within this section of the report:

Structure Group	Structure	WG Structure Name	WG Asset No.	Comment
Watercourse crossings - minor	S101	Ty Hên Culvert	A487 550 C68	Crossings of ordinary watercourses, small main river crossings, and provision for minor field ditches.
	S109A	Pen Y Bryn Culvert 3	A487 601 C01	
	S110A	Pen Y Bryn Culvert 2	A487601 C58	
	S110	Pen y Bryn Culvert 1	A487 601 C73	
	S111A	Bryn Mafon Culvert 1	A487 611 C08	
	S111B	Bryn Mafon Culvert 2	A487 611 C09	
	S112A	Bodrual Culvert 2	A487 621 C61	
	S112B	Bodrual Culvert 1	A487 621 C59	
Watercourse crossings – Afon Rhyd and Afon Cadnant	S102	Afon Rhyd Culvert	A487 565	River Rhyd.
	S114	Afon Cadnant Cattle Creep / Culvert	A487 631	River Cadnant – but combined with cattle creep. See Underbridges.
	S114A	Lon Glai Culvert	A487 631 C08	River Cadnant
	S115A	Bethel Road Culvert 1	A487 635 C01	River Cadnant tributary.
	S115B	Bethel Road Culvert 2	A487 635 C03	River Cadnant tributary.
Large Box Underbridges	S101A	Pont Parc Underpass	A487 561	Side road.
	S105	Dinas Accommodation Underpass	A487 575	Accommodation track.
	S107	Pont Llydiart Gwyn	A487 585	Side road.
	S111	Pont Bryn Mafon	A487 611	Side road.
	S113A	FP 36	A487 625	Footpath and watercourse.
	S114	Afon Cadnant Cattle Creep / Culvert	A487 631	Cattle creep and water course.

Structure Group	Structure	WG Structure Name	WG Asset No.	Comment
Overbridges	S103	Ty'n Llan Overbridge	A487 571	Side Road.
	S109	Pont Ceriw NMU Overbridge	A487 601	NMU bridge.
	S115	Bethel Road Overbridge	A487 635	Side Road.
Underbridge	S108	Pont Cefnwerthyd	A487 591	Crosses WHR.
Afon Gwyrfai Viaduct	S106	Afon Gwyrfai Viaduct	A487 581	Crosses Afon Gwyrfai flood plain.
Afon Seiont Viaduct	S112	Pont Afon Seiont Newydd	A487 621	Crosses Afon Seiont flood plain.
Ancillary Structures and Strengthened Slopes	None identified			

6.2 Watercourse Crossings - Minor

6.2.1 Introduction

For the purposes of the assessment of watercourse crossings, two design categories have been established. This section of the report discusses options specific to the culverting of ordinary watercourses, small main river crossings, and provision for minor field ditches, as tabulated below.

Structure Group	Structure	WG Structure Name	WG Asset No.	Comment
Watercourse crossings - minor	S101	Ty Hên Culvert	A487 550 C68	Crossings of ordinary watercourses, small main river crossings, and provision for minor field ditches.
	S109A	Pen Y Bryn Culvert 3	A487 601 C01	
	S109B	Pen Y Bryn Culvert 4	N/A	
	S110A	Pen Y Bryn Culvert 2	A487601 C58	
	S110	Pen y Bryn Culvert 1	A487 601 C73	
	S111A	Bryn Mafon Culvert 1	A487 611 C08	
	S111B	Bryn Mafon Culvert 2	A487 611 C09	
	S112A	Bodrual Culvert 2	A487 621 C61	
	S112B	Bodrual Culvert 1	A487 621 C59	
	S112C	Bodrual Culvert 3	N/A	

For details of options relating to the culverting of the main river crossings of the Afon Rhyd and Afon Cadnant, refer to Section 6.3.

6.2.2 Opening sizes and conduit choice

Watercourse culvert opening sizes will largely be dictated by the inspection and maintenance-driven requirements of the respective Technical Approval Authorities (TAA). Consultation with Welsh Government TAA has indicated a minimum 1.8m diameter opening for culverts beneath the trunk road network would allow an acceptable inspection and maintenance regime to be adopted, whilst consultation with Gwynedd County Council (GCC) has indicated 1.5m diameter culverts would allow a similar acceptable inspection and maintenance regime to be adopted for the culverts beneath side roads. These TAA requirements essentially take precedence over the design hydraulic requirements, which invariably require smaller diameter conduits.

Culverting of field ditches and other small man-made watercourses will be undertaken using small diameter pipes, typically of 0.6m diameter – a decision based on cost grounds, where the requirement to use the larger diameter culverts specified for

ordinary watercourses/main rivers is not justified given the nominal flows associated with these field ditches.

Piped culverts will be used as the preferred conduit section for culvert crossings of watercourses and minor field ditches – with diameters standardised at 1.8m, 1.5m, and 0.6m. This is the most cost-effective and construction-efficient means of providing these crossings and no alternative conduit types (e.g. precast box culverts) have been considered.

Note that Structure S113A FP36 Underbridge (WG Asset No. A487 625) is a structure which accommodates both a footpath and provision for a minor ditch diversion within a 0.7m wide by 0.3m deep channel section alongside the footpath. This structure is described in more detail in Section 6.4 below.

Conduit diameters of 900mm or less are not classified as Structures in accordance with *BD2/12 Technical Approval of Highway Structures* Clause 3.3 and thus are not considered further within this Structures Design Options Report.

6.2.3 Environmental considerations

In order to comply with the requirements of the Water Framework Directive (WFD), culvert inverts will be depressed relative to approach and exit channels and an invert of natural material will be introduced. Bed thickness will range from 150mm to 300mm depending on the size of the culvert being used.

Where watercourses and ditches have been identified as having potential to support animal movement corridors, 'bolt-on' mammal ledges will be incorporated into the culvert barrel to allow free passage in accordance with the requirements of HA81/99. It is envisaged that ledges, with an appropriate freeboard and headroom allowance can be accommodated within the 1.5m and 1.8m diameters currently specified at these locations.

The location of certain culverted watercourses and ditches has been identified as potentially corresponding to bat flight paths. In these instances, it is believed that the 1.5m and 1.8m diameter culverts would prove sufficient to accommodate bat activity.

6.2.4 Trash and debris screens

The requirement for trash/debris screens will be assessed in accordance with current EA/Defra guidance which considers both blockage risk and the risk of the potential for non-permitted access by members of the public. However, preliminary risk assessments suggest that trash/debris screens will only be required for culverts of 0.6m diameter.

6.2.5 Headwalls

At this stage, it is assumed that headwall inlets and outlets will be formed in either pre-cast or in-situ concrete with a plain concrete finish to all exposed elements. A series of standard designs will be developed, and these will then be assigned to the locations along the scheme. The earthworks will be trimmed locally to match the profile of the headwall units to address any minor variations between the standard unit and the general slope profile.

Proprietary steel tubular post and rail pedestrian guardrails will be provided to the headwalls to prevent falls from height.

6.2.6 Recommendations

It is recommended that the following provision be made for minor watercourse crossings:

Structure	WG Asset No.	Type	Trash/Debris Screen	Environmental Considerations
S101	A487 550 C68	1.8m dia. pipe	No	Bat flight path.
S104	A487 571 C80	1.5m dia. pipe	No	Bat flight path. Animal ledge
S109A	A487 601 C01	1.8m dia. pipe	No	Bat flight path. Animal ledge
S109B	N/A	0.6m dia. Pipe*	Yes	Bat flight path.
S110	A487 601 C73	1.8m dia. pipe	No	Bat flight path.
S110A	A487 601 C58	1.8m dia. pipe	No	Bat flight path.
S111A	A487 611 C08	1.8m dia pipe	Yes (grille)	Bat flight path. Note - bat only culvert – no watercourse.
S111B	A487 611 C09	1.5m dia. pipe	No	Bat flight path.
S112A	A487 621 C61	1.5m dia. pipe	No	Bat flight path.
S112B	A487 621 C59	1.5m dia. pipe	No	Bat flight path.
S112C	N/A	0.6m dia. Pipe*	Yes	Bat flight path.
* Not considered as a “Structure” in accordance with BD2/12				

6.3 Watercourse Crossings – Afon Rhyd and Afon Cadnant

6.3.1 Introduction

This section of the report discusses options specific to the culverting of main river crossings, as tabulated below.

Structure Group	Structure	WG Structure Name	WG Asset No.	Comment
Watercourse crossings – Afon Rhyd and Afon Cadnant	S102	Afon Rhyd Culvert	A487 565	River Rhyd.
	S114	Afon Cadnant Cattle Creep / Culvert	A487 631	River Cadnant – but combined with cattle creep. See Underbridges.
	S114A	Lon Glai Culvert	A487 631 C08	River Cadnant
	S115A	Bethel Road Culvert 1	A487 635 C01	River Cadnant tributary.
	S115B	Bethel Road Culvert 2	A487 635 C03	River Cadnant tributary.

6.3.2 Opening sizes and conduit choice

The Afon Rhyd and Afon Cadnant and its tributary constitute larger watercourses than those discussed in section 6.2, with additional designations as statutory main rivers (and hence the more onerous freeboard requirements that this stipulates).

The design preference for conduit sizes is still to prioritise the use of large diameter (1.8m, diameter) piped culverts where feasible. However, the requirement for a cattle-creep at S114, and the relatively large flows of the Afon Rhyd (S102), will likely dictate the requirement for box culverts at these locations.

The cattle-creep at S114 is likely to require a box underpass with internal dimensions of 3.4m by 3.4m. This would allow the formation of a walkway of width 2.7m (including 0.4m allowance for a parapet and associated upstand) to be located adjacent to a 0.7m deep by 0.7m wide channel which will be used to convey the Afon Cadnant. Structure S114 is therefore discussed further within the Underbridge section of the report below.

Cover restrictions to the carriageway above, coupled with freeboard requirements to the river below, will likely require the maximum internal depth of the S102 box culvert to be limited to 1.8m. Preliminary hydrological design inputs have indicated that a corresponding width of circa 3.2m would be required to convey design flows with appropriate freeboard allowance. A cast in-situ or proprietary pre-cast reinforced concrete box culvert is therefore proposed for Structure S102 Afon Rhyd Culvert.

6.3.3 Headwalls

Standard headwalls will be used for piped culverts, as described in Section 6.2 above. Box culverts will be provided with bespoke splayed wingwalls.

6.3.4 Environmental considerations

Again, in order to comply with the requirements of the Water Framework Directive (WFD), the culvert inverts will be depressed relative to approach and exit channels and an invert of natural material will be introduced. Bed thickness will range from 150mm to 300mm depending on the size of the culvert being used.

Where watercourses and ditches have been identified has having potential to support animal movement corridors, 'bolt-on' mammal ledges will be incorporated into the culvert barrel to allow free passage in accordance with the requirements of HA81/99. It is envisaged that ledges, with an appropriate freeboard and headroom allowance can be accommodated within the 1.8m diameter and larger box culverts currently specified at these locations.

The location of certain culverted watercourses and ditches has been identified as potentially corresponding to bat flight paths. In these instances, it is believed that the 1.8m diameter culverts and larger box culverts specified would prove sufficient to accommodate bat activity.

6.3.5 Culverts – trash and debris screens

6.3.6 The requirement for trash/debris screens will be assessed in accordance with current EA/Defra guidance which considers both blockage risk and the risk of the potential for non-permitted access by members of the public. However, preliminary risk assessments suggest that trash/debris screens will not be required at these structures.

6.3.7 Recommendations

It is recommended that the following provision be made for watercourse crossings of the Afon Rhyd and Afon Cadnant:

Structure	WG Asset No.	Type	Trash/Debris Screen	Environmental Considerations
S102	A487 565	3.2m x 1.8m (WxH) cast in-situ or proprietary pre-cast reinforced concrete box culvert.	No	Bat flight path.
S114	A487 631	3.4m x 3.4m (WxH) cast in-situ or proprietary pre-cast reinforced concrete box culvert.	No	Bat flight path. Animal ledge.
S114A	A487 631 C08	1.8m pipe	No	Bat flight path. Animal ledge.
S115A	A487 635 C01	1.8m pipe	No	Bat flight path. Animal ledge.

Structure	WG Asset No.	Type	Trash/Debris Screen	Environmental Considerations
S115B	N/A	1.8m pipe	No	Bat flight path.

6.4 Large Box Underbridges

6.4.1 Introduction

This section of the report discusses options specific to the underbridges as tabulated below:

Structure Group	Structure	WG Structure Name	WG Asset No.	Comment
Large Box Underbridges	S101A	Pont Parc Underpass	A487 561	Side road.
	S105	Dinas Accommodation Underpass	A487 575	Accommodation track.
	S107	Pont Llydiart Gwyn	A487 585	Side road.
	S111	Pont Bryn Mafon	A487 611	Side road.
	S113A	FP 36	A487 625	Footpath and watercourse.
	S114	Afon Cadnant Cattle Creep / Culvert	A487 631	Cattle creep and water course.

At the outset of Key Stage 3, a number of underbridge structures were identified as being required along the length of the scheme to accommodate both side road crossings and private accommodation track crossings below the A487 main line. It was acknowledged that consultation with various stakeholders taking place early in Key Stage 3 would possibly amend the number of structures required, their location, and their geometric cross section, and indeed, this has been the case as the scheme design has evolved to date.

The underbridge structures along the scheme typically form the high spots along the A487 main line vertical alignment, and so the combination of the required headrooms above the obstacles below and the construction depth of the bridge deck superstructure are all constraints which typically inform the vertical alignment and consequently the earthworks requirements along the scheme.

Since the proposed A487 main line cross section at each of the underbridge locations is to be similar, the approach adopted for the purposes of this report has been to develop a number of underbridge options based on the typical cross sectional geometry exhibited by three of the public side road underbridges, namely:

Structure	WG Structure Name	WG Asset No.	Comment	Outline Geometry
S101A	Pont Parc Underpass	A487 561	Side road.	2.3m verge, 3.7m carriageway, 1.2m verge. 5.3m min headroom.
S107	Pont Llydiart Gwyn	A487 585	Side road.	2.3m verge, 3.7m carriageway, 1.2m verge. 5.3m min headroom.

Structure	WG Structure Name	WG Asset No.	Comment	Outline Geometry
S111	Pont Bryn Mafon	A487 611	Side road.	2.3m verge, 3.7m carriageway, 1.2m verge. 5.3m min headroom.

It is acknowledged that the geometrical sections will vary between underbridges appropriate to their purpose, but the constraints and issues identified will typically be equally applicable irrespective of geometry, and hence conclusions drawn from the study of one particular structure will be largely applicable to all within the group. Where this is not the case, appropriate commentary is provided.

6.4.2 Headroom and Lateral Clearance Constraints

All overbridge structures above public highways are to provide 5.3m minimum headroom above surfaces within the “Structure Free Zone”.

The cross section of the underbridges through which public side roads pass have been developed to provide a minimum 6.6m wide opening envelope in accordance with Clause 5.4 of *TD27/05 Cross-Sections and Headrooms*.

It is proposed that Statutory Undertakers’ (SUs) apparatus along side road structures be accommodated in ducts/sleeves located within the verge construction. The level of the base slab is to be set to provide an adequate depth of verge construction to accommodate the various SUs’ apparatus. Casting the ducts/sleeves into concrete verge construction will allow SU apparatus to be fed or pulled through from one end of the structure, and will provide resistance to damage from the effects of accidental vehicle loading along the verge. The proposed principles of SU apparatus arrangement within Structure S107 Pont Llydiart Gwyn Underbridge (WG Asset No. A487 585) are depicted in Figure 1 below.

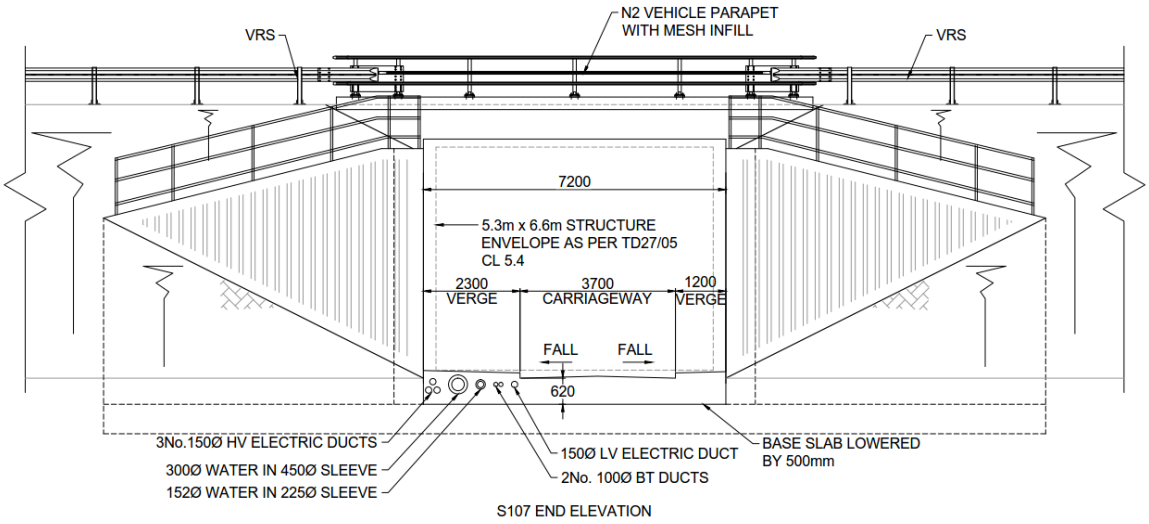


Figure 1 – Typical Section through Box Structure illustrating SU Apparatus Provision within Verge Construction above Base Slab

The headroom requirements for private accommodation track crossings vary by agreement with the land owner and/or user, depending on use. Proposed geometrical

sections are consistent with the outcome of engagement with the affected land owners/users during Key Stage 3 to date.

The headroom requirements for pedestrian underpasses are in accordance with *TD36/93 Subways for Pedestrians and Pedal Cyclists - Layout and Dimensions*, i.e. 2.3m headroom for lengths of less than 23m, increasing to 2.6m for subways greater than 23m length.

6.4.3 Span arrangements and choice of construction materials

Based on the three similar public side road underbridge structures, a clear span of 7.2m is required in order to accommodate the side road carriageway with associated verges to either side.

Note that an allowance has been made at this stage for the inclusion of lighting units to the uppermost corners of the box section. However, it is envisaged that there will be no requirement for lighting, and there may be an opportunity to reduce the clear span to 6.6m during the remainder of Key Stage 3 following formal agreement to lighting requirements and further consultation with the Statutory Undertakers regarding provision to be made within the side road verges at the structures.

The following options for underbridge construction have been considered:

- Option 1 - In-situ reinforced concrete box;
- Option 2 - Box structure comprising precast pre-stressed concrete beam top slab above in-situ reinforced concrete side walls and base slab;
- Option 3 - Precast concrete 'Opti-Cadre' box;
- Option 4 – Arch forms.
- Option 5 – Portal forms.

Access for maintenance for all structural forms will be from the A487 highway alignment above, or from the roads or accommodation tracks below.

Each of the underbridge options identified above is briefly described below.

For each of the options, consideration has been given to:

- Outline construction methodology.
- Review of the proposed structural form against the Context for Structures and Other Factors Affecting Choice identified in Sections 4 and 5, respectively, above.
- Comparative capital cost for construction.
- Comparative whole life cost with due regard to maintenance requirements during the working life of the structure.

6.4.4 OPTION 1 - In-situ reinforced concrete box

<u>Description</u>

Option 1 comprises:

- In-situ reinforced concrete box (base slab, side walls and roof slab).

- It is proposed that Statutory Undertakers' apparatus be accommodated in ducts/sleeves accommodated within the wide verge.
- Reinforced concrete wingwalls.
- Note that reinforced soil wingwalls, with hard-faced vertical concrete panels, could also be constructed in lieu of reinforced concrete wingwalls.

Option 1 is illustrated in Figures 2 to 4 below.

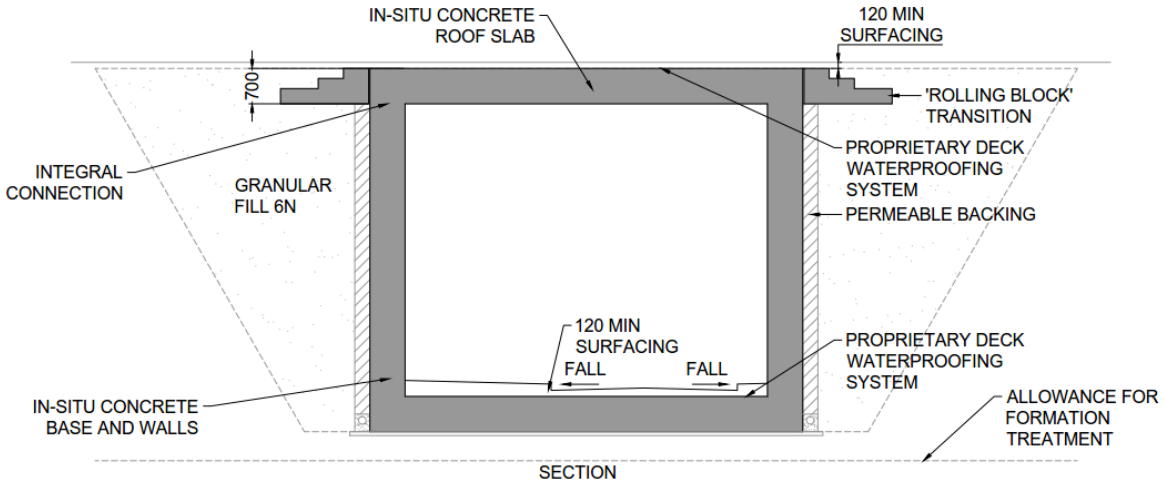


Figure 2 – Option 1 - Typical Section

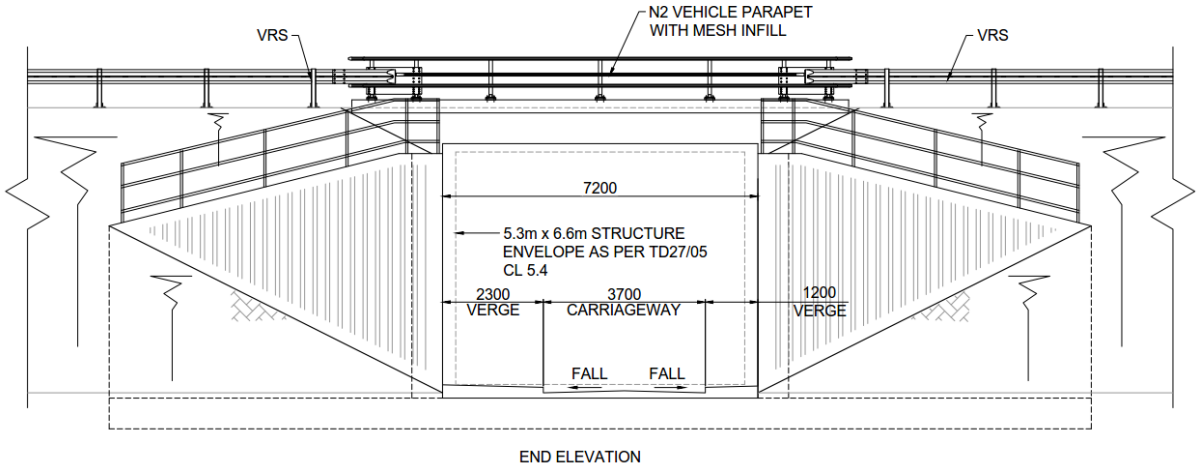


Figure 3 – Option 1 - Typical End Elevation

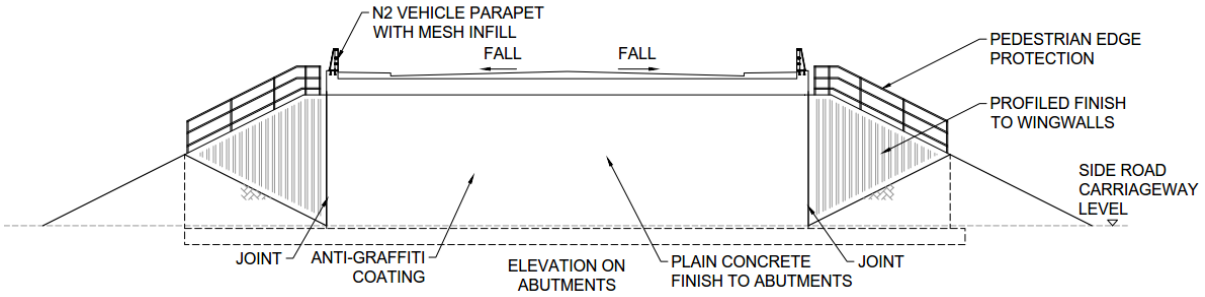


Figure 4 – Option 1 - Typical Elevation on Abutments and Wingwalls

Outline Construction Sequence

The outline construction sequence would be:

- Either temporarily close or temporarily divert side road if required.
- Undertake formation treatment if required.
- Construct in-situ reinforced concrete base slab to box and wingwall bases.
- Construct in-situ reinforced concrete side walls to box and wingwall wall stems.
- Erect falsework and formwork, and construct in-situ reinforced concrete deck slab.
- Strike soffit formwork to deck slab and dismantle falsework.
- Backfill box side walls and wing walls.
- Complete finishes – waterproofing, parapets, kerbs, surfacing, SU provision, etc.

Aesthetics and Landscape Effects - Family of structures,

A plain concrete surface is proposed to the internal walls. A Class F4 finish would allow embedded ties in a regular pattern to be deployed.

Wingwalls could be orientated in any direction. However, a plan orientation at approximately 45 degrees to the side road alignment would minimise the potential risk of vehicular impact with the end of the wingwall compared with a wingwall alignment running parallel to the side road carriageway below, and typically leads to the shortest overall wingwall length compared with other wingwall orientations.

It is proposed that the visible expanse of wingwall be broken up with feature grooves at regular centres, which can be used to disguise formwork ply lines and embedded ties deployed between the front and rear shutter faces to resist the hydrostatic concrete pour pressures.

The adoption of similar wingwall details to underbridge structures along the scheme could be utilised to create a “family” of details for the scheme.

Highway Alignment and Earthworks Balance – Impacts beyond the bridge location

A box structure provides an economical form of construction for the span range proposed. Impacts on the main line vertical alignment can be optimised through the balance of raising the main line alignment to pass over the underbridge, and lowering the side road alignment to pass below the structure. The degree to which the side road can be lowered is typically driven by the ability to continue to drain the side road from the low point invariably created at the crossing point.

Overall Construction Methodology and Approach and Safe by Design

Maintenance of haul route

The haul route will typically be interrupted during construction of the box structure, and will typically be routed around the structure until it is completed.

Whilst it is normal practice to complete the box structure in its entirety prior to backfilling, there is also the opportunity to backfill the wall stems prior to completion of the top slab pour to allow slightly more rapid construction, subject to consideration of this load case in the design of the structure.

Transportable

There are no particular difficulties envisaged in transporting the reinforcement and in-situ concrete to the points of construction.

Erectable/Buildability & Programme

The bridge form is simple to construct, and is of familiar construction, meaning that construction is usually relatively rapid.

Safe to construct

Construction of the bridge deck requires erection of falsework/formwork at height to effect a soffit shutter. Following completion of the deck pour, and attainment of the concrete strength, the formwork would be released and the falsework dismantled. This is a common form of construction for structures of this span range.

Unauthorised access to soffit

At 5.3m headroom and with a flat deck soffit, there would be no issues associated with unauthorised access to the deck soffit.

Durability - Maintenance for future durability

An in-situ concrete box structure is a durable structural form with an anticipated low maintenance liability.

Access for inspection can be gained from both the highway above, and the side road below the structure under appropriate traffic management. Touching distance access to the soffit could be gained from a scaffold tower or MEWP under a closure of the side road. Alternatively, with light traffic flows along the side road, it may be possible to undertake such works by holding traffic at a stop either side of the work site, and manually allowing progress through the site once the carriageway has been cleared of any temporary obstruction.

Environment - Noise, local air quality, greenhouse gas emissions, land-take and transport

Material delivery, including the delivery of in-situ concrete, is anticipated to be along the site haul route, thereby minimising the impact of construction traffic on the local road network.

A box structure provides an efficient section with minimal construction depth thereby, minimising the effects of landtake associated with any side road vertical re-alignment and A487 main line “high” spots.

Comparative Construction Cost

The comparative cost of the in-situ reinforced concrete box is £384,000.

Comparative Whole Life Cost

Since the maintenance liability of the in-situ reinforced concrete box solution is similar to the alternative solutions, no comparative whole life maintenance cost has been determined.

6.4.5 OPTION 2 - In-situ reinforced concrete box incorporating pre-cast concrete roof slab elements

Description

Option 2 is very similar to Option 1, but incorporates pre-cast concrete elements into the roof slab. Option 2 therefore comprises:

- In-situ reinforced concrete base slab and side walls.
- Roof slab comprising precast concrete beam-type elements with in-situ concrete topping to form solid slab integral with side walls to create box structure.

The Section for Option 2 is illustrated in Figure 5 below. Note that the typical end elevation, and the elevation on the abutments and wingwalls would be as proposed for Option 1.

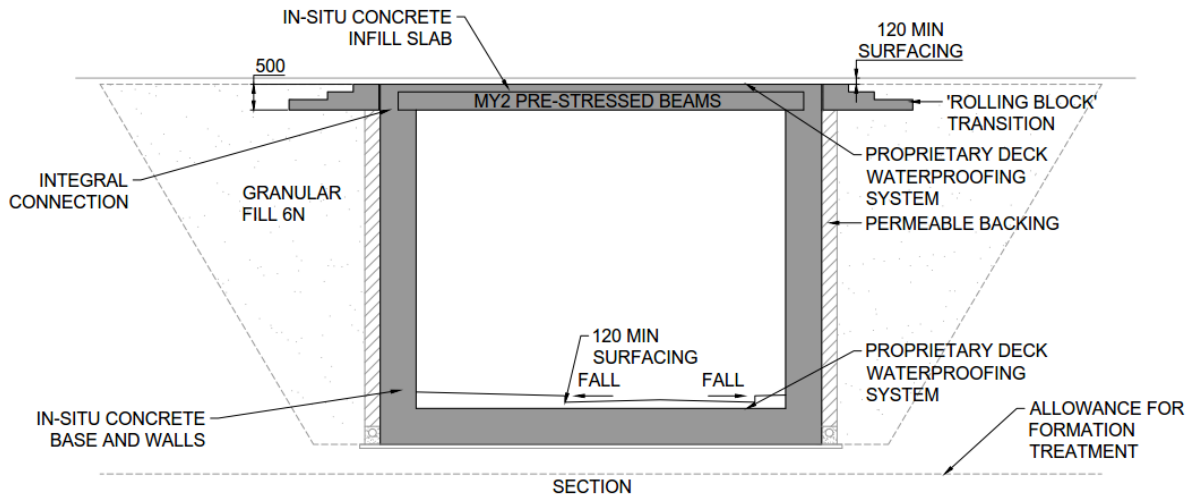


Figure 5 – Option 2 - Typical Section

Outline Construction Sequence

The outline construction sequence would be:

- Either temporarily close or temporarily divert side road if required.
- Undertake formation treatment if required.
- Construct in-situ reinforced concrete base slab to box and wingwall bases.
- Construct in-situ reinforced concrete side walls to box and wingwall wall stems.
- Land pre-cast concrete beams to form closed roof slab soffit.
- Fix deck reinforcement, and pour in-situ concrete topping to deck beams to form solid roof slab with fully integral connection to abutment side walls.
- Backfill box side walls and wing walls.
- Complete finishes – waterproofing, parapets, kerbs, surfacing, SU provision, etc.

Aesthetics and Landscape Effects - Family of structures,

The proposed finishes and wingwall orientation would be as per Option 1. The roof slab soffit would, however, comprise a series of pre-cast beam soffits as opposed to a plain solid slab concrete soffit.

Highway Alignment and Earthworks Balance – Impacts beyond the bridge location

As for Option 1, a box structure provides an economical form of construction for the span range proposed. There is scope to adopt a slightly more slender deck construction (potentially in the order of 200mm thinner), which could offer a minor benefit in terms of side road tie-in lengths.

Overall Construction Methodology and Approach and Safe by Design

Maintenance of haul route

The haul route will typically be interrupted during construction of the box structure.

However, a roof slab incorporating pre-cast concrete elements is likely to offer some construction programme savings over Option 1, as the need to falsework is removed.

Like Option 1, mitigation for haul road disruption could be achieved via the backfilling of the wall stems prior to completion of the top slab pour.

Transportable

There are no particular difficulties envisaged in transporting the reinforcement and in-situ concrete to the points of construction. The pre-cast elements are eminently transportable, being of very low weight and length.

Erectable/Buildability & Programme

The bridge form is simple to construct, and is of familiar construction, meaning that construction is usually relatively rapid. The use of pre-cast concrete elements within the roof slab, and the elimination of falsework, are likely to provide construction programme savings over Option 1.

Safe to construct

Option 2 eliminates the need to erect and dismantle formwork at height, offering a health and safety construction advantage over Option 1.

Unauthorised access to soffit

At 5.3m headroom and with a flat deck soffit, there would be no issues associated with unauthorised access to the deck soffit.

Durability - Maintenance for future durability

An in-situ concrete box structure is a durable structural form with an anticipated low maintenance liability. Factory production of pre-cast concrete elements forming the soffit to the roof slab would typically provide a more durable and higher quality finish than Option 1.

Access for inspection and maintenance would be as Option 1.

Environment - Noise, local air quality, greenhouse gas emissions, land-take and transport

Material delivery, including the delivery of in-situ concrete, is anticipated to be along the site haul route, thereby minimising the impact of construction traffic on the local road network. Although containing less in-situ concrete than Option 1, the use of more pre-cast elements are likely to result in a similar number of vehicle movements.

Option 2 would require marginally less landtake along the side road compared with Option 1 as a result of the minor reduction in roof slab construction depth.

Comparative Construction Cost

The comparative cost of the in-situ reinforced concrete box incorporating pre-cast concrete elements into the roof slab is £425,000.

Comparative Whole Life Cost

Since the maintenance liability of Option 2 is similar to Option 1, no comparative whole life maintenance cost has been determined.

6.4.6 OPTION 3 – Proprietary Pre-Cast Concrete Box – Opti-Cadre System

Description

Option 3 consists of a reinforced concrete box constructed largely from pre-cast components based on the Opti-Cadre system, supplied under licence in the UK by ABM Europe.

The Opti-Cadre system is based on the soil-structure inter-action between frame-shaped precast reinforced concrete structures and the surrounding backfill material in order to provide relatively slender concrete sections. It should be noted, however, that whilst the resulting pre-cast sections are relatively slender, there is a requirement to provide a minimum 500mm cover above the structural roof slab in order to invoke the soil-structure interaction, and thus the total depth of the fill and the roof slab exceeds that of Options 1 and 2 above.

One of the principal advantages of the Opti-Cadre system is that it allows very rapid construction from factory-produced structural precast elements.

In summary, Option 3 comprises:

- Pre-cast reinforced concrete L-shaped base slab and lower side walls units.
- Pre-cast flat base slab unit.
- An in-situ reinforced concrete stitch to join the L-units to the base slab units.
- Pre-cast u-shaped roof slab and upper side wall unit.

The pre-cast units are typically provided in 2.5m widths to allow transportation from the pre-cast facility to site. The horizontal connection between the walls and the roof is of ball-socket type and is modelled as a hinge joint with a ball on the roof element and socket on the wall element. The horizontal joint position is established from consideration of a variety of permanent and live loads and the resulting deflection behaviour. The “ball/socket” joint is dry and allows the structure to deflect and thus activate the backfill interaction. Vertical joints between units are typically 20mm wide. Waterproofing of the joints is achieved via the introduction of hydrophilic water-stops and bandage seals to supplement conventional buried concrete surfacing waterproofing.

As the units are standard, the required square spans are usually achieved to the nearest 0.5m span clearance. In addition, the system lends itself to construction of square structures. Skew structures would be accommodated through provision of an over-long box, for which detailed consideration would need to be given to the VRS and parapet provision which typically need to run parallel to the A487 main line above.

For the wingwalls, the most common solution is the use of retaining wall sections fromed from precast “L” shaped units. These are fabricated in the same mould as the wall elements but with the top edge sloped.

Design of the foundations to support the pre-cast units is the responsibility of the main contractor, and hence a holistic approach to design, checking and construction, as for reinforced soil, is required.

Option 3 is illustrated in Figures 6 to 10 below.

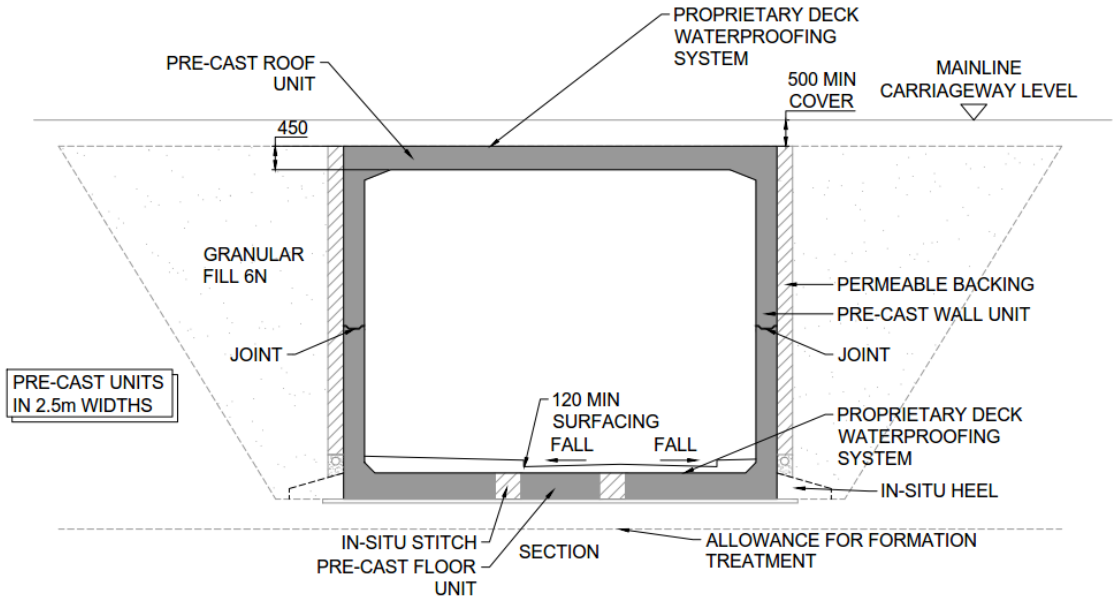


Figure 6 – Option 3 - Typical Section

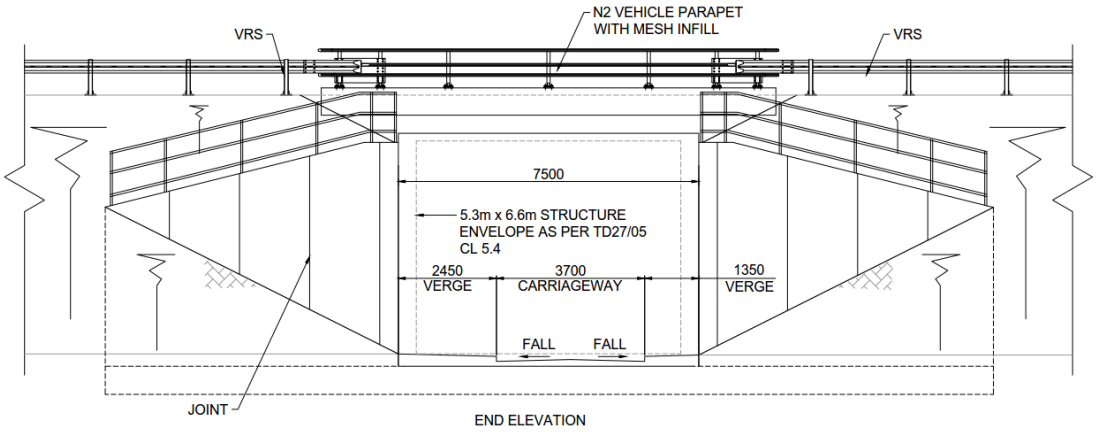


Figure 7 – Option 3 - Typical End Elevation

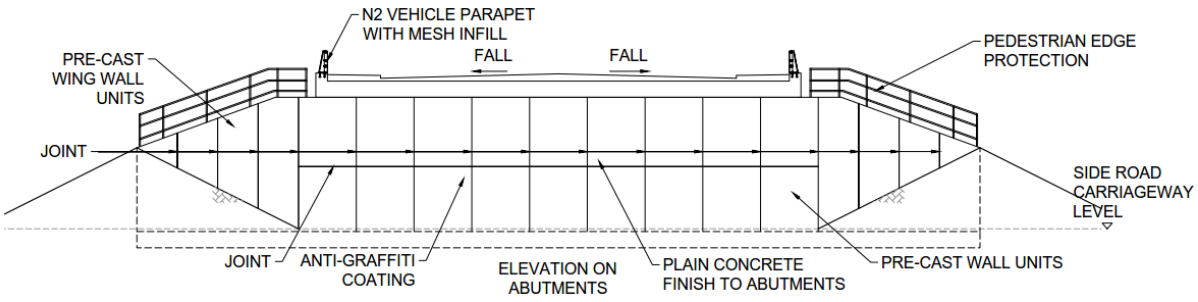


Figure 8 – Option 3 - Typical Elevation on Abutments and Wingwalls

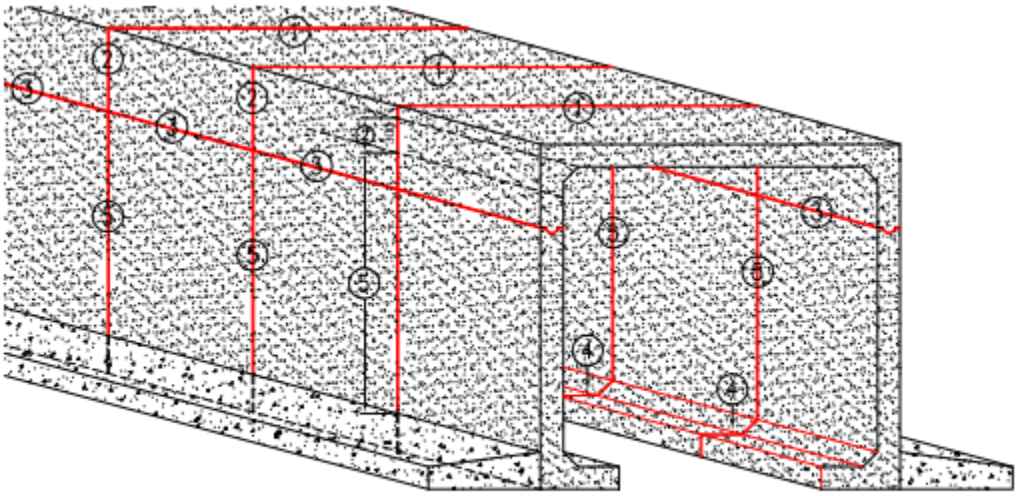


Figure 9 – Option 3 – Joints requiring waterproofing, depicted in red, based on information provided by ABM Europe

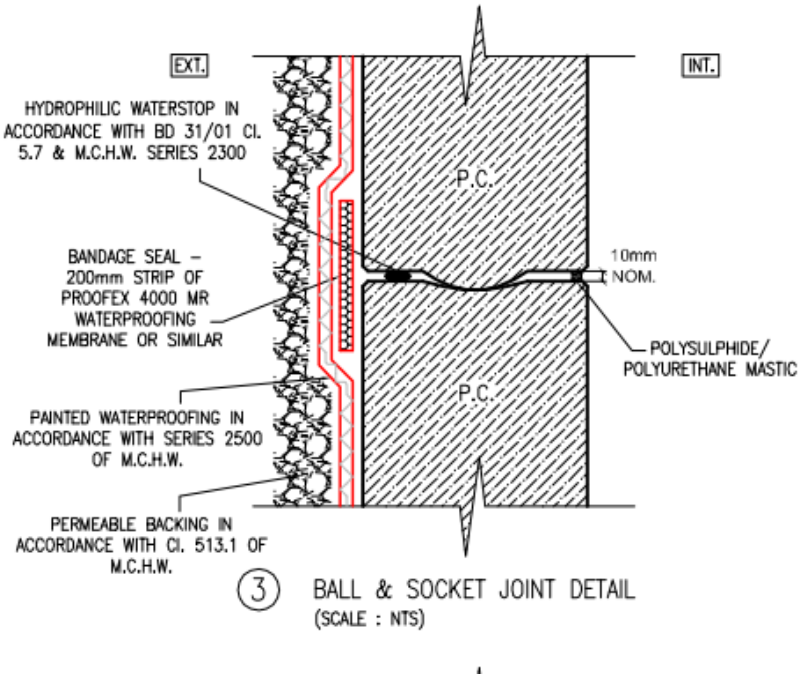


Figure 10 – Option 3 – Horizontal joint waterproofing detail abstract based on information provided by ABM Europe

Outline Construction Sequence

The outline construction sequence would be:

- Either temporarily close or temporarily divert side road if required.

- Undertake formation treatment if required and construct appropriate foundations to receive pre-cast units.
- Land pre-cast L-shaped units to form part base and lower wall.
- Land pre-cast L-shaped units to wingwalls.
- Land precast floor slab (if utilised) .
- Land pre-cast concrete u-shaped roof slab units beams to form closed roof slab soffit.
- Construct in-situ stitch between wall and floor to complete box.
- Backfill box side walls and wing walls.
- Complete finishes – waterproofing, parapets, kerbs, surfacing, SU provision, etc.

Aesthetics and Landscape Effects - Family of structures,

The proposed wingwall orientation would be as per Option 1.

The roof slab soffit and walls would each comprise a myriad of visible joints, which in the long term, could be prone to unsightly leakage.

Highway Alignment and Earthworks Balance – Impacts beyond the bridge location

Whilst a box structure provides an economical form of construction for the span range proposed, the Opti-Cadre system typically requires approximately 500mm of cover above the roof slab element. The overall construction depth of the system, including the cover, is therefore greater than Options 1 and 2, and thus has a greater adverse effect on the length of side road tie-ins.

Overall Construction Methodology and Approach and Safe by Design

Maintenance of haul route

The haul route will typically be interrupted during construction of the box structure.

However, construction of the Opti-Cadre pre-cast system is very rapid compared with both Options 1 and 2, with completion of the structural elements including the wingwalls taking as little as two weeks.

Transportable

The structure is constructed from a number of pre-cast units, for which delivery would be required from the pre-cast factory on the public road network. The pre-cast elements are eminently transportable.

Erectable/Buildability & Programme

The bridge form is very rapid to construct, and has the potential to provide a reduced impact on the haul road compared with Options 1 and 2. Waterproofing is more difficult than for Options 1 and 2, as there are a multitude of joints requiring treatment prior to backfilling.

The detailing for the element to support the vehicle restraint system across the structure requires some careful consideration for skew structures.

Safe to construct

Option 3 eliminates the need to erect and dismantle formwork at height, and largely removes the need to fix reinforcement on site with the resultant benefits in terms of manual handling.

Unauthorised access to soffit

At 5.3m headroom and with a flat deck soffit, there would be no issues associated with unauthorised access to the deck soffit.

Durability - Maintenance for future durability

Pre-cast units produced under factory conditions are typically of a higher quality and hence more durable than in-situ alternatives.

However, the introduction of a number of vertical and horizontal joints throughout the structure has the potential to introduce a maintenance liability associated with potential joint leakage over the life of the structure. Remediation of any leakage would be difficult to achieve.

Access for inspection and maintenance would be as Option 1.

Environment - Noise, local air quality, greenhouse gas emissions, land-take and transport

Material delivery, including the delivery of in-situ concrete, is anticipated to be along the site haul route, thereby minimising the impact of construction traffic on the local road network. Where the movements for in-situ concrete for Options 1 and 2 all have their start and end points within the length of the site, the starting point of the pre-cast element journey is likely to be remote from the site involving some additional movements on the national road network.

Option 3 would require marginally more landtake along the side road compared with Options 1 and 2 as a result of the increase in roof slab and fill construction depth, and as a result of the need to over-extend structures supporting a side road skew to the mainline to provide a square end.

Comparative Construction Cost

The comparative cost of the Opti-Cadre pre-cast concrete box solution is £534,000.

Comparative Whole Life Cost

The maintenance liability of Option 3 is likely to be higher than Options 1 and 2 as a result of the significant number of sealed joints present between the various pre-cast units, all of which have the potential for leakage with associated degradation of the adjoining concrete surfaces throughout the life of the structure. However, since the comparative capital works cost of Option 3 already exceeds the more durable forms for Options 1 and 2, no further work has been undertaken to compute a comparative whole life cost, other than to note the cost differential between Option 3 and Options 1 and 2 will increase still further.

6.4.7 OPTION 4 - Arch Forms (Corrugated Steel and Precast Concrete Arches)

The underbridge structures are typically each a constraint to the main line vertical alignment. They form a relative high spot in the main line, and as such, their construction form and hence construction depth very much influences the cut/fill balance for the scheme. The greater the construction depth, the higher the main line alignment needs to be, and hence the greater the amount of fill (and hence cut) required.

Arch-type forms do not lend themselves to minimal construction depths by virtue of both the curved soffit profile needing to provide headroom clearance over the full side road section below (i.e. the "Structure Free Zone" (SFZ)), and the need to place fill above the crown to achieve inherent strength and stability. In addition, with little fill above, the spans tend to be excessive in order to provide headroom clearance to the SFZ. A typical configuration is illustrated in Figure 11 below.

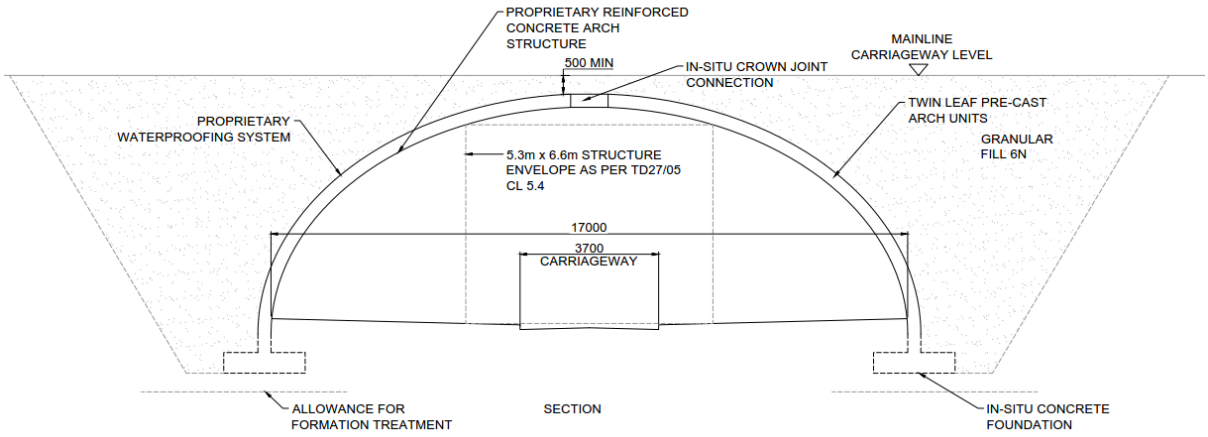


Figure 11 – Typical Arch Form Configuration in Low Cover Scenario

Arch forms do not offer an appropriate, economical solution and have therefore not been considered further for the underbridge structures.

6.4.8 OPTION 5 - Portal Forms

Portal frame structures typically require foundation widths to the abutment walls in the order of 70% of the retained height. For the underbridge structures considered in this section, the total length of the foundations to each abutment would far exceed the width of the base slab required to form a box. Furthermore, the toe to such foundations would generally project forward of the front face of the wall stem extending below the verge and potentially into the carriageway.

Portal forms do not offer an appropriate, economical solution for the underbridge span range and have therefore not been considered further for the underbridge structures.

6.4.9 Summary of Comparative Capital Works Costs for Side Road Underbridges

A summary of the comparative capital works costs for the side road underbridge options is presented in the table below.

	Superstructure Materials			
	In-situ reinforced concrete box	**In-situ reinforced concrete box incorporating pre-cast deck elements**	**Opti-Cadre Box**	**Arch and Portal forms**
	Option 1	**Option 2**	**Option 3**	**Options 4 & 5**
Capital Cost	£384,000	£425,000	£534,000	N/A

6.4.10 Summary of Comparative Whole Life Costs for Side Road Underbridges

The maintenance liability of Option 3 is likely to be higher than Options 1 and 2 as a result of the significant number of sealed joints present between the various pre-cast units. However, since the comparative capital works cost of Option 3 already exceeds the more durable forms for Options 1 and 2, no further work has been undertaken to compute a comparative whole life cost, other than to note the cost differential between Option 3 and Options 1 and 2 will increase still further.

6.4.11 Recommendation for Side Road Underbridges

Based on the summary of comparative capital and whole life costs, together with the review of the structural forms against the Context for Structures and Other Factors Affecting Choice identified in Sections 4 and 5, respectively, then it is recommended that side road underbridge structures comprise either Option 1 or Option 2, i.e. either:

- Option 1 - In-situ reinforced concrete box
- Option 2 - Box structure comprising precast pre-stressed concrete beam top slab above in-situ reinforced concrete side walls and base slab.

It should be noted that, as a generic costing exercise, no detailed assessment of site specific temporary works for carriageway diversions has been included. Consideration of this on a site specific basis will dictate the solution to be proposed, as there may be locations for which falsework is not favoured.

6.4.12 Applicability and Recommendations for Actual Overbridge Locations

As the scheme has developed through Key Stage 3, the geometry requirements for the underbridges have been agreed as follows with the relevant stakeholders:

Structure	WG Structure Name	WG Asset No.	Comment	Outline Geometry
S101A	Pont Parc Underpass	A487 561	Side road.	2.3m verge, 3.7m carriageway, 1.2m verge. 5.3m min headroom.
S105	Dinas Accommodation Underpass	A487 575	Accommodation access track	0.5m verge, 3.5m PMA, 0.5m verge. 4.5m min headroom.
S107	Pont Llydiart Gwyn	A487 585	Side road.	2.3m verge, 3.7m carriageway, 1.2m verge. 5.3m min headroom.
S111	Pont Bryn Mafon	A487 611	Side road.	2.3m verge, 3.7m carriageway, 1.2m verge. 5.3m min headroom.
S113A	FP 36	A487 625	Footpath and watercourse.	2.3m footpath including handrail. 0.7m channel. 2.3m min headroom.
S114	Afon Cadnant /Cattle Creep	A487 631	Cattle creep and River Cadnant water course.	2.7m cattle creep including parapet, 0.7m channel. 2.7m min headroom.

Screen shots from the draft highway Layout Approval Plans are included in this section of the report to provide an understanding of the setting for the proposed underbridges, noting that the Layout Plans are under parallel development and are being refined towards a final deliverable.

6.4.12.1 S101A Pont Parc Underpass (WG Asset No. A487 561)

A preliminary plan of the structure location is illustrated in Figure 12 below.

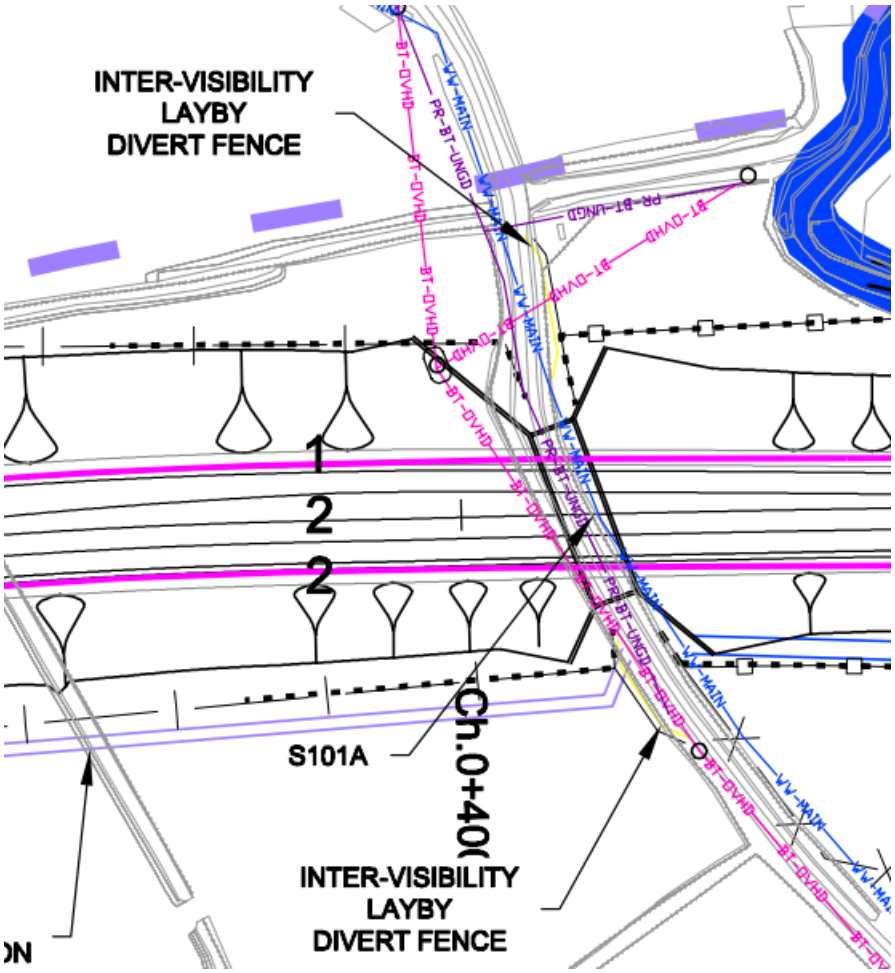


Figure 12. Draft Layout Plan abstract showing plan of Structure S101A

Options 1 or 2 can be constructed on line following either a temporary diversion or a temporary closure of the side road. Inter-visibility between passing places to be provided either side of the structure has been checked through the structure box along the side road for the proposed alignment. This proposal allows the side road width through the structure to be minimised to match the existing side road width, thereby minimising the structural span and associated costs.

Existing Statutory Undertakers' apparatus to be retained at this location is indicated in Section 4.6 above. It is envisaged that it would need to be either temporarily diverted around or temporarily supported and protected through the underbridge site during construction, until the permanent diversion provision is made within the verge construction.

The box structure could be configured with skew ends running parallel with the A487 main line above, at a skew angle of approximately 19 degrees.

Structure sections, end elevations and abutment and wingwall elevations would be as presented in Sections 6.4.4 and 6.4.5 above. The General Arrangement for the structure, based on recommended Options 1 or 2, is contained in Appendix D.

6.4.12.2 S105 Dinas Accommodation Underpass (WG Asset No. A487 575)

A preliminary plan of the structure location is illustrated in Figure 13 below.

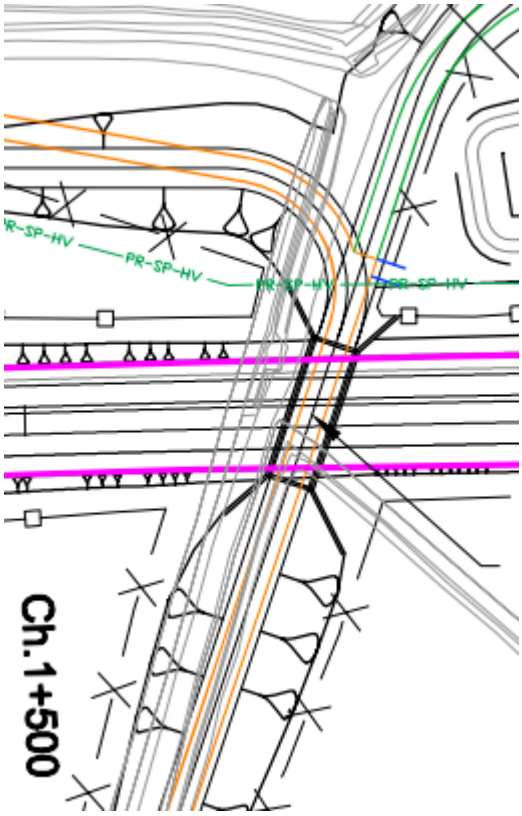


Figure 13. Draft Layout Plan abstract showing plan of Structure S105

The structure is provided to accommodate a private means of access – a farm accommodation track - within a cutting below the proposed A487 main line. A headroom of 4.5m is proposed above a 3.5m wide track bounded by 0.5m verges to the abutment faces.

The structure is a “hard spot” along the A487 main line with approximately 5500mm nominal cover to be provided above the bridge deck waterproofing to the top slab of the box. It has been confirmed that the structure can be drained from its low point, despite being constructed within a localised cutting.

The box structure could be configured with skew ends running parallel with the A487 main line above, at a skew angle of approximately 20 degrees.

Options 1 or 2 can therefore be readily constructed at this location.

The General Arrangement for the structure, based on recommended Options 1 or 2, is contained in Appendix D.

6.4.12.3 S107 Pont Llydiart Gwyn (WG Asset No. A487 585)

A preliminary plan of the structure location is illustrated in Figure 14 below.

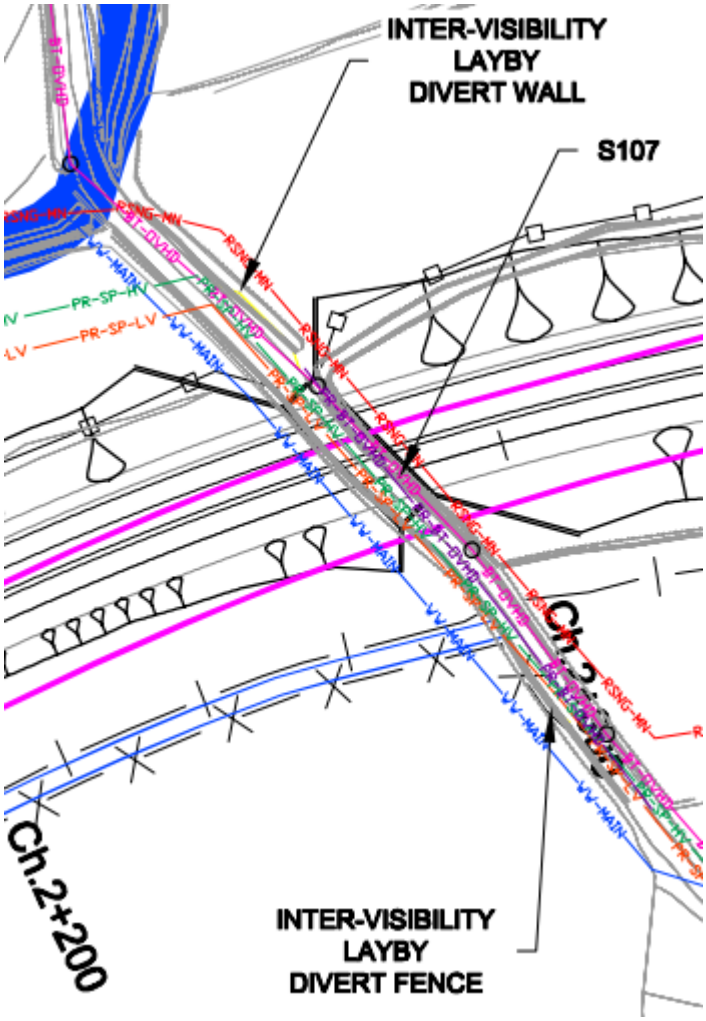


Figure 14. Draft Layout Plan abstract showing plan of Structure S107

Options 1 or 2 can be constructed on line following either a temporary diversion or a temporary closure of the side road. Inter-visibility between passing places to be provided either side of the structure has been checked through the structure box along the side road for the proposed alignment. This proposal allows the side road width through the structure to be minimised to match the existing side road width, thereby minimising the structural span and associated costs.

Existing Statutory Undertakers' apparatus to be retained at this location is indicated in Section 4.6 above, and further illustrated in Section 6.4.2 above. It is envisaged that it would need to be either temporarily diverted around or temporarily supported and protected through the underbridge site during construction, until the permanent diversion provision is made within the verge construction.

The box structure could be configured with skew ends running parallel with the A487 main line above, at a skew angle of approximately 27 degrees.

Structure sections, end elevations and abutment and wingwall elevations would be as presented in Sections 6.4.4 and 6.4.5 above. The General Arrangement for the structure, based on recommended Options 1 or 2, is contained in Appendix D.

6.4.12.4 S111 Pont Bryn Mafon (WG Asset No. A487 611)

A preliminary plan of the structure location is illustrated in Figure 15 below.

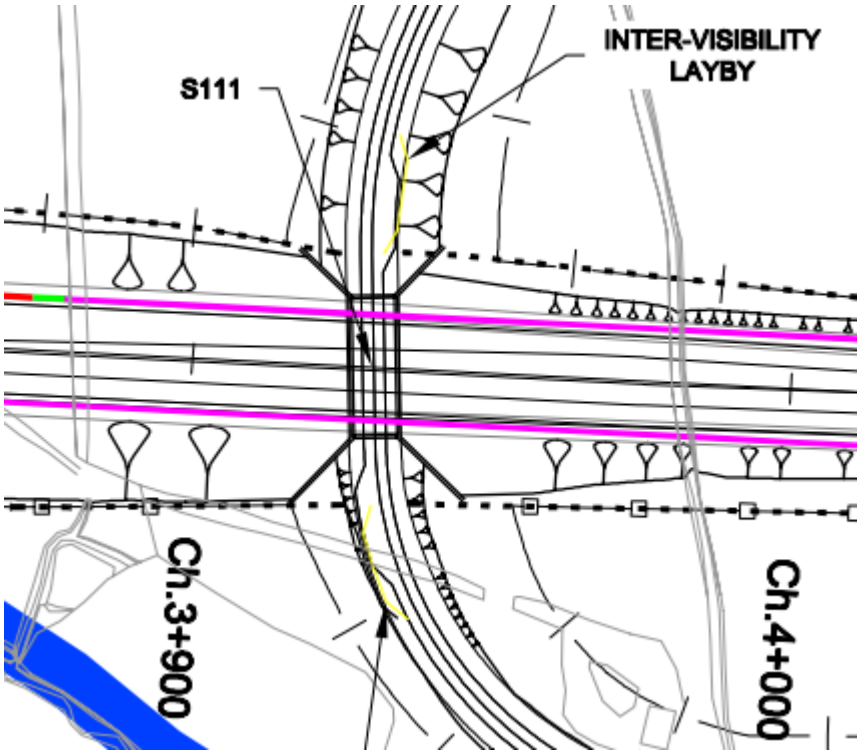


Figure 15. Draft Layout Plan abstract showing plan of Structure S107

Options 1 or 2 can be constructed off-line. Inter-visibility between passing places to be provided either side of the structure has been checked through the structure box along the side road for the proposed alignment. This proposal allows the side road width through the structure to be minimised to match the existing side road width, thereby minimising the structural span and associated costs.

Statutory Undertakers' apparatus to be accommodated at this location is indicated in Section 4.6 above, and would be permanently diverted into the structure within the verge construction following completion.

The box structure could be configured with skew ends running parallel with the A487 main line above, at a skew angle of approximately 4 degrees.

Structure sections, end elevations and abutment and wingwall elevations would be as presented in Sections 6.4.4 and 6.4.5 above. The General Arrangement for the structure, based on recommended Options 1 or 2, is contained in Appendix D.

6.4.12.5 S113A FP36 Underpass (WG Asset No. A487 625)

A preliminary plan of the structure location is illustrated in Figure 16 below.

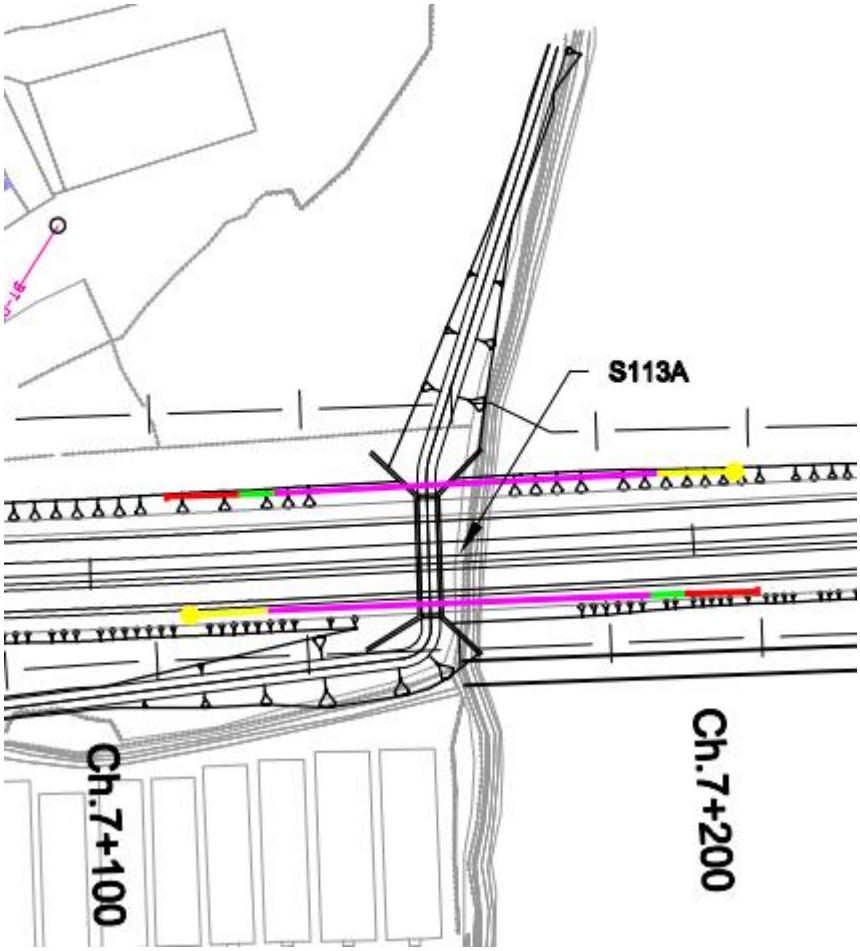


Figure 16. Draft Layout Plan abstract showing plan of Structure S113A

The structure is provided to accommodate Public Footpath 36 within a cutting below the proposed A487 main line. The structure length is less than 23m, and hence 2.3m headroom is proposed to the footpath element. The structure is to be combined with a drainage ditch. The geometrical constraints at this location lend themselves to a box structure with a clear opening of 3.0m wide by 2.6m high.

The structure is a “hard spot” along the A487 main line, currently with 950mm nominal fill to be provided above the bridge deck waterproofing to the top slab of the box. It has been confirmed that the structure can be drained from its low point, despite being constructed within a localised cutting.

Option 1, an in-situ reinforced concrete box, could be readily constructed at this location. However, the opening dimensions are noted as being much smaller than those considered in the comparison of underbridge options above. The smaller opening size lends itself to the construction of a reinforced concrete box section using proprietary pre-cast box units, readily available from numerous pre-cast suppliers, as a viable alternative for this location, and this is therefore recommended.

The General Arrangement for the structure, based on the recommended option constructed from proprietary precast reinforced concrete units, is contained in Appendix D.

6.4.12.6 S114 Afon Cadnant /Cattle Creep (WG Asset No. A487 631)

A preliminary plan of the structure location is illustrated in Figure 17 below.

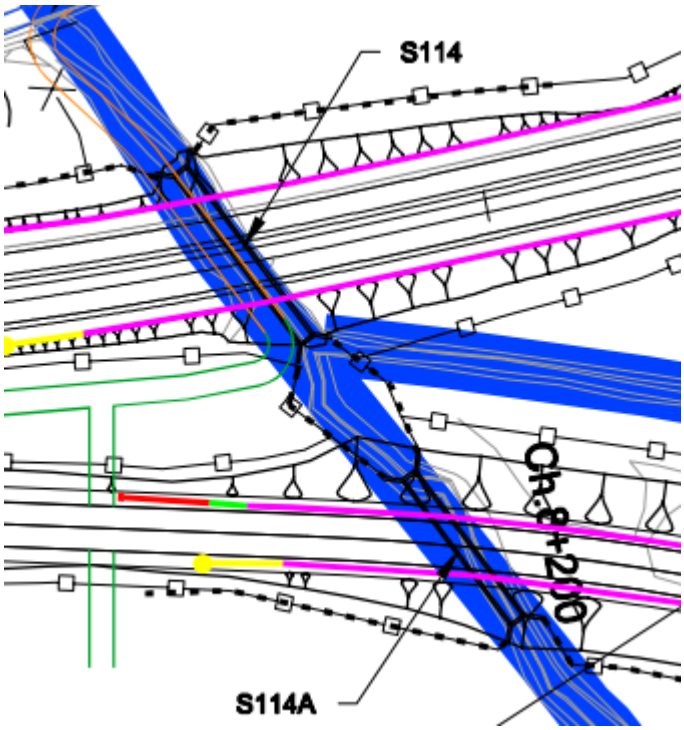


Figure 17. Draft Layout Plan abstract showing plan of Structure S114

The structure is provided to accommodate both a cattle-creep and the Afon Cadnant river (see Section 6.3 above).

A box of 3.4m x 3.4m internal dimensions is proposed. This would allow the formation of a walkway of width 2.7m (including 0.4m allowance for a parapet and associated upstand) to be located adjacent to a 0.7m deep by 0.7m wide channel which will be used to convey the Afon Cadnant. A headroom of 2.7m is to be provided above the cattle creep element.

The structure is a “hard spot” along the A487 main line with 750mm nominal cover currently provided above the bridge deck waterproofing to the top slab of the box.

Option 1, an in-situ reinforced concrete box, could be readily constructed at this location. The box structure could be configured with skew ends running parallel with the A487 main line above, at a skew angle of approximately 22 degrees.

However, the opening dimensions are again noted as being much smaller than those considered in the comparison of underbridge options above. The smaller opening size lends itself to the construction of a reinforced concrete box section using proprietary pre-cast box units, readily available from numerous pre-cast suppliers, as a viable alternative for this location. For a proprietary pre-cast reinforced concrete box solution, the ends could be made square with earthworks then trimmed locally around

the wingwalls to suit. A pre-cast option also removes the need to pour large quantities of in-situ concrete nor watercourses. Given the smaller size, a pre-cast option is recommended for this structure.

The General Arrangement for the structure, based on the recommended option constructed from proprietary precast reinforced concrete units, is contained in Appendix D.

6.5 Overbridges

6.5.1 Introduction

At the outset of Key Stage 3, there were four overbridge structures which passed over the A487 mainline, requiring a clear main span in the order of 20 metres. In addition, there was an underline structure supporting the A487 main line above the Welsh Highland Railway, requiring a clear main span in the order of 16 metres, for which a similar structural form to the overbridges was proposed. It was also acknowledged that consultation with various stakeholders was to take place early in Key Stage 3 which had the potential to identify further overbridge structures that may need to be provided as part of the scheme.

With numerous highway design iterations for both the main line and side roads, ground investigation works, topographical survey works, iterations for earthworks to achieve a cut fill balance, Public Information Exhibitions and other stakeholder liaison, all progressing in parallel during the early part of Key Stage 3, and with any recommendations informing the bridge provision (even as fundamental as overbridge versus underbridge) then coming near the end of the programmed period for production of a Design Options Report, the challenges of providing a number of Options for each particular bridge location for an evolving design in a restricted programme have been considerable.

Since the proposed A487 main line geometry at each of the overbridge locations is to be similar, the approach adopted for the purposes of this report has been to develop a number of overbridge options based on the typical geometry exhibited by one of the overbridges. It is acknowledged that the deck cross sections vary between the overbridges in order to accommodate differing width carriageways and verges for the roads they support, but the constraints and issues identified will typically be equally applicable irrespective of bridge width, and hence conclusions drawn from the study of one particular structure will be largely applicable to all within the group. Where this is not the case, appropriate commentary is provided.

The findings of the work undertaken have then been summarised. Finally, the findings have been applied to the proposed structures as applicable, cognisant of the actual constraints at any particular location, in order to arrive at a series of recommended options.

The crossing of the Welsh Highland Railway on Structure S108 Pont Cefnwerthyd (WG Asset No. A487 591) is covered separately below, but draws heavily on the overbridge work presented in this section of the report. Similarly, consideration of options for a further underbridge over the A4085 as part of the Structure S112 Pont Afon Seiont Newydd crossing of the Afon Seiont (WG Asset No. A487 621) also draws on this section of the report.

6.5.2 Headroom and Lateral Clearance Constraints

All overbridge structures are to provide 5.3m minimum headroom above surfaces within the “Structure Free Zone”. Where piers or abutments are to be provided in relatively close proximity to the main line carriageway, these will be set out at the back of the verge in order to accommodate sight lines, and to allow the provision of a vehicle restraint system and carriageway drainage details past the substructures.

6.5.3 Span arrangements and choice of construction materials

At each of the overbridge locations, the site geometry and constraints lend themselves to consideration of the options tabulated below.

Access for maintenance for all structural forms will be from the A487 highway alignment below, or from the roads or accommodation tracks above.

	Superstructure Materials			
Span arrangement	**Steel concrete composite multi-beam deck**	**Steel concrete composite ladder deck**	**Pre-cast pre-stressed concrete beam deck**	**In-situ reinforced concrete deck**
3 span superstructure	Option 1	Option 2	Option 3	Option 4
c.20m single span superstructure	Option 5	Option 6	Option 7	Option 8
c.30m single span superstructure	Option 9	Option 10	Option 11	Option 12

Each of the overbridge options identified above is briefly described below.

For each of the options, consideration has been given to:

- Outline construction methodology.
- Review of the proposed structural form against the Context for Structures and Other Factors Affecting Choice identified in Sections 4 and 5, respectively, above.
- Comparative capital cost for construction.
- Comparative whole life cost with due regard to maintenance requirements during the working life of the structure.

Whilst this consideration is presented as a narrative under each of the option headings below, it is appreciated that comparison between options and the relative merits become difficult to retain and are somewhat repetitive, so to this end, both a narrative summary table and an overview summary table are included at the end of the overbridge section to assist in assimilation of information.

Principal element sizes have been typically determined from a combination of preliminary sizing exercises, use of available look-up tables and/or manufacturers' data sheets, blended with experience of similar structural forms on other highway schemes.

6.5.4 OPTION 1 - 3 Span Steel Concrete Composite Multi Beam Superstructure

Description

Option 1 comprises:

- 3 span steel concrete composite superstructure with parallel steel beams.
- Reinforced concrete leaf piers and reinforced concrete bankseat abutments, currently assumed founded on spread footings for option comparison. Piled supports could readily be accommodated.

- Supported on bearings and continuous over intermediate piers. Fully integral with bankseat abutments.
- Deck end joint details would likely comprise a simple saw cut joint through the surfacing, as opposed to a proprietary asphaltic plug joint which commonly serve to block the sub-surface drainage path from the deck, are supported off elements of vastly different vertical stiffnesses, and often introduce an un-necessary maintenance liability.

Option 1 is illustrated in Figures 18 and 19 below.

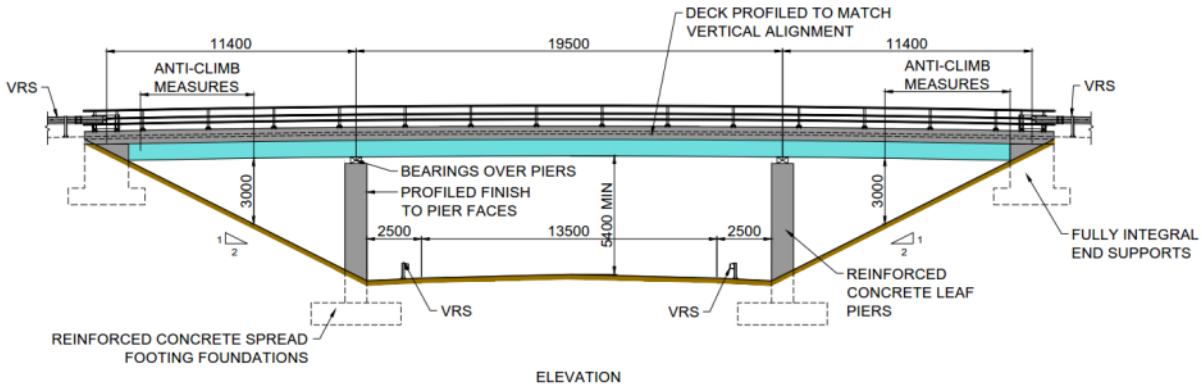


Figure 18 – Option 1 Elevation

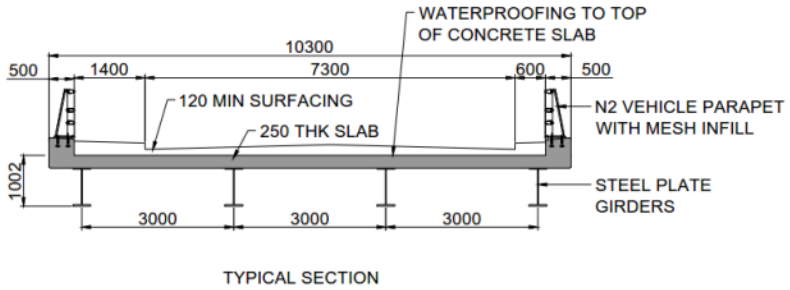


Figure 19 – Option 1 Deck Section

Outline Construction Sequence

The outline construction sequence would be:

- Construct reinforced concrete pier and bankseat foundations.
- Construct reinforced concrete leaf piers.
- Install bearings above piers.
- Deliver steel beams to site and lay down.
- Assemble steel beams as braced pairs at ground level, attach edge protection.
- Lift all braced pairs of steel beams to back span 1, extending to splice point in centre span 2. Lift all braced pairs of steel beams to centre span 2, extending to

splice point in back span 3, completing splices. Lift all braced pairs of steel beams in back span 3, completing splices.

- Erect permanent formwork to form deck soffit between beam top flanges.
- Fix deck reinforcement, pour in-situ concrete deck and integral connection to bankseat abutments.
- Backfill bankseat abutments.
- Complete finishes – waterproofing, parapets, kerbs, surfacing, etc.

Aesthetics and Landscape Effects -Family of structures, Open aspect/aesthetics

The structural form provides an open aspect with a family of structures readily achievable.

The contrast between the painted steel beams and the reinforced concrete stringcourse to the deck elevations, the relatively slender deck, together with the ability to readily accommodate larger deck edge cantilevers than Option 3, all typically lead to the provision of an aesthetically superior structure compared with the other overbridge options.

Highway Alignment and Earthworks Balance – Impacts beyond the bridge location

Of all of the overbridge options, this structural form provides the least construction depth, and the use of steel allows the superstructure to be profiled in elevation to follow the vertical alignment of the side roads. It therefore has the least impact beyond the limits of the bridge site, minimising the length of side road diversion and land-take needed to provide tie-ins.

Overall Construction Methodology and Approach and Safe by Design

Maintenance of haul route

This bridge form can readily be constructed without obstructing the haul route along the site, and is thereby aligned with the overall scheme philosophy.

Transportable

Fabricated steel beams are relatively lightweight, and can be delivered to site in short lengths and spliced on site prior to erection as required.

Erectable/Buildability & Programme

The bridge form is simple to construct, and is of familiar construction, meaning that erection and completion is usually rapid.

Safe to construct

The lifting of braced pairs of beams provides an inherently stable solution. Edge protection can be assembled at ground level prior to erection. Permanent formwork provides a closed soffit for safe working at height for all subsequent construction operations at height.

Simple, familiar, standard-type details all lend themselves to safe construction.

Unauthorised access to soffit

There are no bearings at the integral bankseat end supports, and hence no enclosures are required.

Despite the rural location, there is a perception that unauthorised access could be gained to the superstructure near the bankseat abutments, which have little clearance to the ground level slope down to the A487 main line. The beam depths and flange widths are such that the likelihood of members of the public walking or crawling along the flanges would be negligible, and that unauthorised access activities would more likely constitute the use of the bottom flanges as hand holds to facilitate aerial access across the back spans. Detailing could be introduced to the bottom flanges to prevent such access to a point where the beams have approximately 3m headroom between ground and soffit level – see Figure 20.

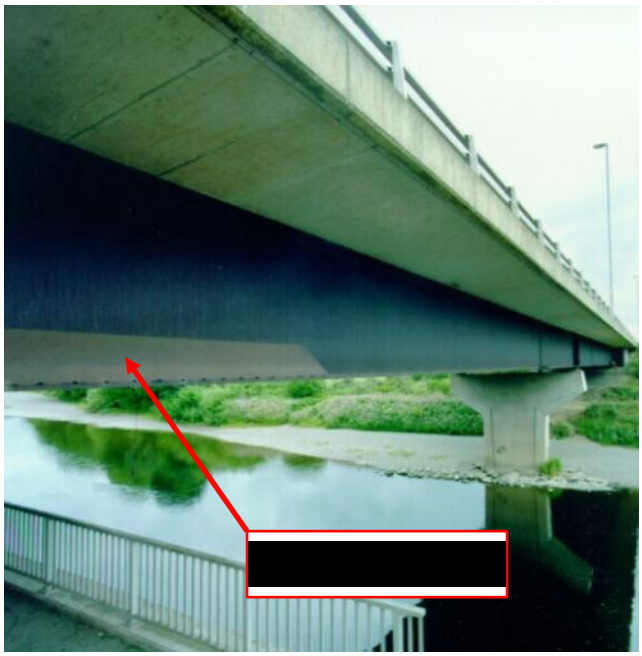


Figure 20 – Access Deterrent

Durability - Maintenance for future durability

One of the disadvantages of a steel composite superstructure compared with pre-stressed concrete or reinforced concrete alternatives is the need to undertake painting activities through the design life of the bridge. A complete grit-blast and repaint of the structural steelwork will typically be required at approximately 25 year intervals. This activity will require traffic management on the A487 and the provision of enclosures around the superstructure steelwork for the grit-blast and repainting activities. In addition, a mid-term maintenance intervention will typically be required to address minor breakdown of the protective treatment system and ensure that the 25 year major maintenance cycle is achieved.

The solution also proposes mechanical bearings above the piers, which would require maintenance painting under the same painting regime as the structural steelwork, and potential replacement at 60 year intervals.

Environment - Noise, local air quality, greenhouse gas emissions, land-take and transport

Of all of the 3 span overbridge options, this structural form provides the fewest transport moves, the lowest landtake and least visual intrusion associated with the least construction depth and earlier tie-ins along the side road alignments.

The ability to readily accommodate the haul road through the bridge construction site minimises the impact of traffic which would otherwise have to use the local highway network.

Comparative Construction Cost

The comparative construction cost of Option 1 is £431,000.

Comparative Whole Life Cost

The comparative whole life cost of Option 1 is £523,000.

6.5.5 OPTION 2 - 3 Span Steel Concrete Composite Ladder Deck Superstructure

Description

Option 2 comprises:

- 3 span steel concrete composite ladder deck superstructure.
- Discrete reinforced concrete pier columns and reinforced concrete bankseat abutments, currently assumed founded on spread footings. Piled supports could readily be accommodated.
- Supported on bearings and continuous over intermediate column piers. Fully integral with bankseat abutments.
- Deck end joint details would likely comprise a simple saw cut joint through the surfacing.

Option 2 is illustrated in Figures 21 and 22 below.

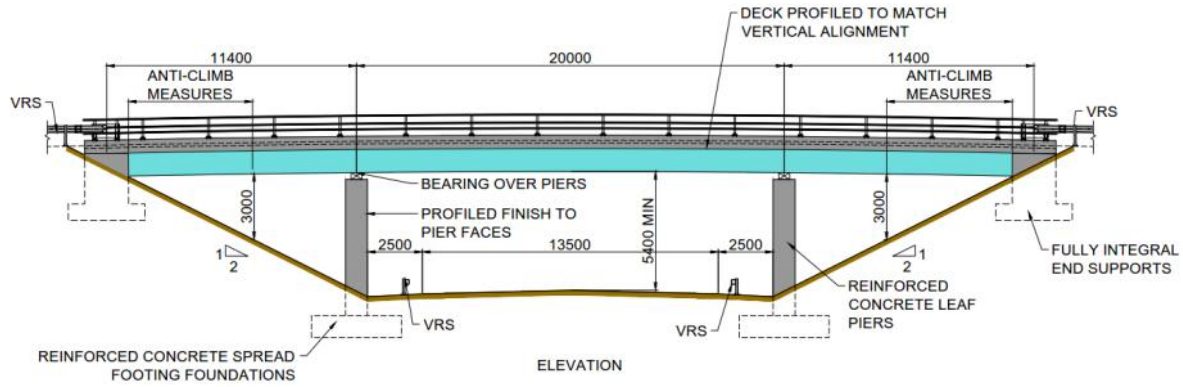


Figure 21 – Option 2 Elevation

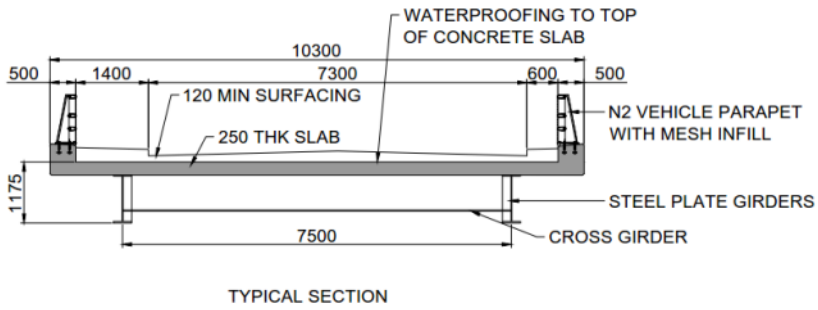


Figure 22 – Option 2 Deck Section

In general, ladder decks usually prove to be economical for spans upwards of 35m to 40m. The aspect ratio of the span lengths to deck width for a 3 span structure, particularly in the back spans, is low, and hence in this situation, a ladder deck is not considered appropriate. In addition, the increased construction depth and longer tie-ins required compared with Option 1 are a relative dis-benefit.

For these reasons, Option 2 has not been considered further.

6.5.6 OPTION 3 - 3 Span Pre-cast Pre-stressed Concrete Beam Superstructure

Description

Option 3 comprises:

- 3 span steel pre-cast pre-stressed concrete beam superstructure.
- Reinforced concrete leaf piers and reinforced concrete bankseat abutments, currently assumed founded on spread footings for option comparison. Piled supports could readily be accommodated.
- Fully integral with intermediate piers and bankseat abutments, with no bearings. Integral connection achieved via cast-in situ diaphragms/stitches which extend some distance from the support positions into the spans.
- Deck end joint details would again likely comprise a simple saw cut joint through the surfacing.

Option 3 is illustrated in Figures 23 to 25 below.

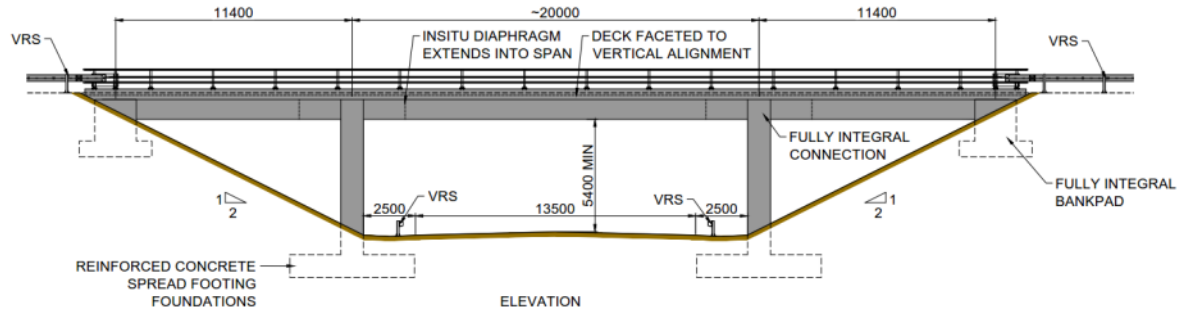


Figure 23 – Option 3 Elevation

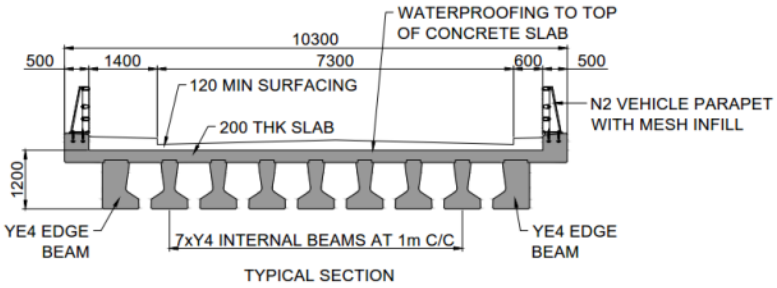


Figure 24 – Option 3 Deck Section

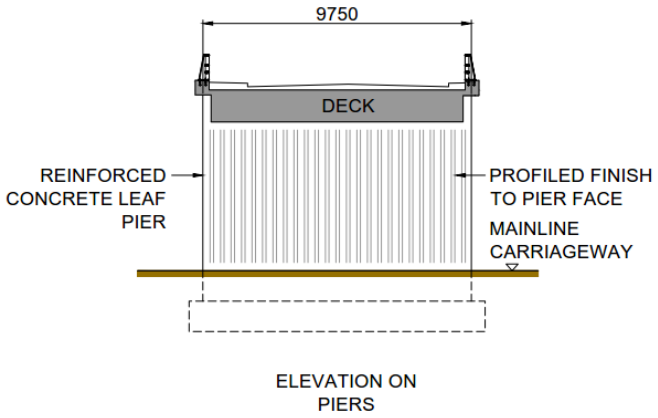


Figure 25 – Option 3 Pier Elevation

Outline Construction Sequence

The complexity of this particular form of construction derives primarily from the integral connection between the intermediate piers and the deck.

The safest from of construction is to land the pre-cast pre-stressed concrete beams on a grout bed above a reinforced concrete leaf pier or pier crosshead. This avoids having to land the beams on temporary supports located some distance in front of the pier faces. The pier needs to be of sufficient width to accommodate the bearing area of the beams in this temporary condition to both sustain the applied actions, and to reduce the risk of the beam falling from the bearing area during construction, whilst still achieving adequate strength in the integral connection.

The piers also need to be robust in order to sustain accidental traffic collision actions, and as they then tend to be of a similar stiffness to the deck, significant moments are attracted to the integral connection between the deck and pier. Reinforcement projecting from the piers needs to be effectively anchored into the deck to cater for the load effects attracted to the integral connection, resulting in the need to either lap or couple bars in the deck with projecting bars from the pier.

To further add to the complexity, long term creep and shrinkage effects in the pre-cast pre-stressed beams requires the provision of either reinforcement or strand projecting from the bottom flanges of the pre-stressed concrete beams into the pier head area,

which needs to be detailed to both provide an anchorage length and to avoid clashing with the reinforcement or strand projecting from the beam in the adjacent span.

Beams with projecting horizontal reinforcement therefore need to be landed on piers with projecting vertical reinforcement. Very careful site controls are needed in fixing of reinforcement and subsequent placement of in-situ concrete to the piers to avoid clashes later on, and then careful control is required in the landing of beams in between the projecting reinforcement. The depth of superstructure construction for a 3 span option is such that the creation of a moment connection between the deck reinforcement and the projecting pier reinforcement may be best achieved via the use of couplers. The fixing of reinforcement between beams to form the diaphragm into the span either side of the piers further complicates construction.

This form of connection is feasible, and is frequently achieved, but the risk of error increases compared with other options, and the need to fix reinforcement into awkward spaces is a risk which could be eliminated through the choice of other structural forms. It should be noted, however, that the construction risk is offset by a reduced health and safety risk associated with bridge maintenance and work at height over the working life of the structure through the elimination of painted structural steelwork and bridge bearings.

The outline construction sequence for Option 3 would therefore be:

- Construct reinforced concrete pier and bankseat foundations.
- Construct reinforced concrete leaf piers to deck soffit level, with projecting reinforcement from pier top into deck.
- Deliver concrete beams to site, attach edge protection at ground level for edge beams, and lift into position on grout bed to piers and bankseats.
- Lift all beams to back span 1, then centre span 2, followed by back span 3, using mobile crane.
- Erect permanent formwork to form deck soffit between beam top flanges.
- Fix deck, pier diaphragm and bankseat abutment integral connection reinforcement.
- Install formwork to diaphragm ends within spans.
- Pour in-situ concrete deck and integral connection to piers and bankseat abutments.
- Strike any temporary formwork.
- Backfill bankseat abutments.
- Complete finishes – waterproofing, parapets, kerbs, surfacing, etc.

<u>Aesthetics and Landscape Effects -Family of structures, Open aspect/aesthetics</u>

The structural form provides an open aspect.

However, pre-stressed concrete beams are typically almost straight in elevation following the application of all dead and superimposed dead load and following the loss of some pre-stress as a result of long term creep and shrinkage effects. Aesthetically, fitting 3 spans of pre-stressed concrete beams to a side road alignment on a vertical curve gives rise to a facetted appearance in elevation, which is

aesthetically undesirable. For aesthetics, then, the side road vertical curve would ideally be a straight grade to accommodate this form of structure.

In addition, the use of pre-cast pre-stressed concrete beams results in a greater construction depth than the steel composite Option 1 alternative. With a small deck edge cantilever casting little shadow, with no contrast in colour between the concrete stringcourse and the concrete beam, and with a greater construction depth compared with Option 1, Option 3 will appear “heavier” than Option 1.

The construction joint between pre-cast pre-stressed concrete beam ends and the pier top is typically unsightly, and masking is usually achieved via the extension of the piers beyond the deck edges to create a masking detail, as depicted in Figure 25 above.

Highway Alignment and Earthworks Balance – Impacts beyond the bridge location

The construction depth is greater than Option 1 and the precast beams are ideally matched to a straight grade vertical side road alignment. Both of these effects serve to increase the height of the embankment on the approaches to the bridge increasing the length of side road diversions and land-take needed to provide tie-ins compared with Option 1.

Overall Construction Methodology and Approach and Safe by Design

Maintenance of haul route

This bridge form can readily be constructed without obstructing the haul route along the site, and is thereby aligned with the overall scheme philosophy.

Transportable

Pre-cast concrete beams of approximately 20m length are relatively lightweight, and can be delivered to site.

Erectable/Buildability & Programme

Whilst the precast beam elements of the structure are simple and quick to erect, the integral tie-ins to the piers are more challenging and time-consuming compared with Option 1.

Safe to construct

The lifting of edge beams with cantilever formwork in place to provide edge protection is typically inherently unstable during erection. Precast concrete stringcourses could be utilised in lieu of an in-situ stringcourse to mitigate such instability during erection. However, temporary works are typically required between all beams to stabilise them from over-turning during construction.

Permanent formwork provides a closed soffit for safe working at height for all subsequent construction operations at height.

Unauthorised access to soffit

There are no bearings at the integral bankseat end supports, and hence no enclosures are required.

With little in the way of handholds, any risk of unauthorised access to the superstructure near the bankseat abutments is considered to be negligible.

Durability - Maintenance for future durability

With no bearings or structural steelwork to maintain or paint, a concrete superstructure provides a significant advantage over Option 1 in terms of future maintenance liability.

Environment - Noise, local air quality, greenhouse gas emissions, land-take and transport

This structural form requires a greater number of beams to be delivered to site compared with Option 1.

Option 3 has a greater landtake and visual intrusion compared with Option 1 by virtue of its greater construction depth, straight vertical alignment profile and longer tie-in lengths along the side road alignments.

The ability to readily accommodate the haul road through the bridge construction site minimises the impact of traffic which would otherwise have to use the local highway network.

Comparative Construction Cost

The comparative construction cost of Option 3 is £494,000 in cut, and £519,000 in fill.

Comparative Whole Life Cost

The comparative whole life cost of Option 3 is £494,000 in cut, and £519,000 in fill.

6.5.7 OPTION 4 - 3 Span In-situ Reinforced Concrete Slab Superstructure

Description

Option 4 comprises:

- 3 span in-situ reinforced concrete slab superstructure.
- Reinforced concrete leaf piers and reinforced concrete bankseat abutments, currently assumed founded on spread footings for option comparison. Piled supports could readily be accommodated.
- Fully integral with intermediate piers and bankseat abutments, with no bearings.
- Deck end joint details would again likely comprise a simple saw cut joint through the surfacing.

Option 4 is illustrated in Figures 26 to 28 below.

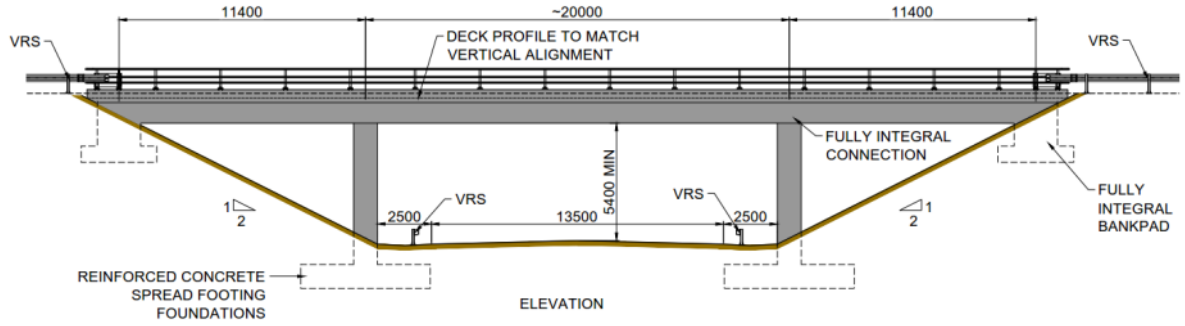


Figure 26 – Option 4 Elevation

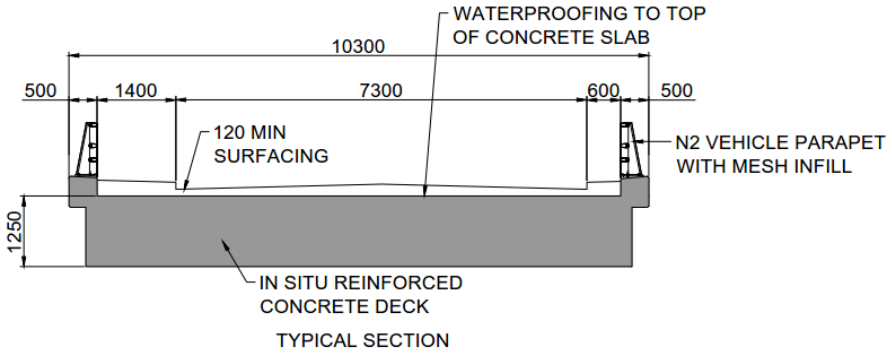


Figure 27 – Option 4 Deck section

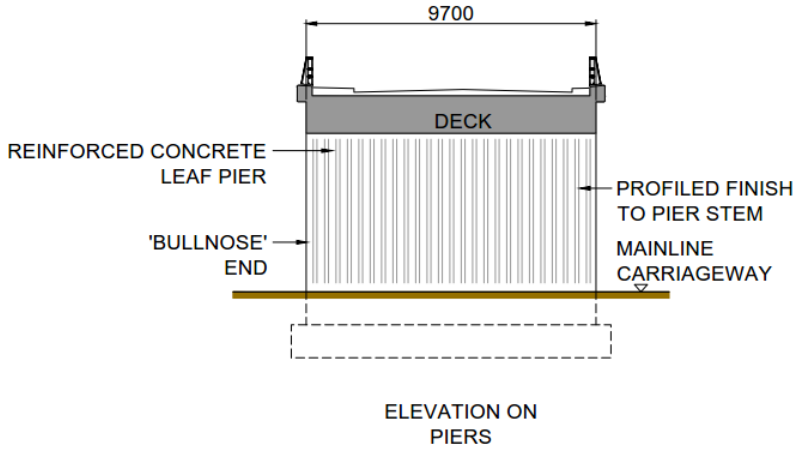


Figure 28 – Option 4 Pier Elevation

Outline Construction Sequence

The complexity of this particular form of construction derives primarily from the need to erect and then remove falsework in order to construct the superstructure.

The outline construction sequence for Option 4 would therefore be:

- Construct reinforced concrete pier and bankseat foundations.
- Construct reinforced concrete leaf piers to deck soffit level, with projecting reinforcement from pier top into deck.
- Erect falsework to form bridge deck soffit.
- Fix deck reinforcement, including that associated with integral connections into piers and bankseats.
- Pour in-situ concrete deck and integral connection to piers and bankseat abutments.
- Strike soffit formwork and remove falsework.
- Backfill bankseat abutments.
- Complete finishes – waterproofing, parapets, kerbs, surfacing, etc.

Aesthetics and Landscape Effects -Family of structures, Open aspect/aesthetics

The structural form provides an open aspect.

Of all of the 3 span overbridge options, this structural form provides the greatest construction depth. Although a small deck edge cantilever casting little shadow has been depicted, there is an opportunity to increase the deck edge cantilever and to deepen the stringcourse in order to both create a shadowing effect to the side of the deck below the stringcourse, and to visually reduce the apparent depth of the deck slab beam to make the deck appear more slender. Despite the greater construction depth, this structure can be made to appear more slender then Option 3.

Highway Alignment and Earthworks Balance – Impacts beyond the bridge location

The use of in-situ reinforced concrete for the superstructure allows the superstructure to be profiled in elevation to follow the vertical alignment of the side roads.

However, of all of the 3 span overbridge options, this structural form provides the greatest construction depth. This serves to increase the height of the embankment on the approaches to the bridge increasing the length of side road diversions and land-take needed to provide tie-ins compared with Options 1and 3 on straight grade side road vertical alignments.

Overall Construction Methodology and Approach and Safe by Design

Maintenance of haul route

The need to erect falsework, pour an insitu reinforced concrete superstructure, await the requisite period for concrete strength gain, and dismantle the falsework will have a greater impact on the operation of the haul route than Options 1 and 3, requiring temporary diversion of traffic around the bridge site during superstructure construction.

Transportable

Reinforcement for this bridge type will generally involve the use of larger diameter and hence heavier reinforcement bars than those needed for the construction of the superstructures to Options 1 and 3, with associated handling on site.

Option 4 will require greater quantities of in-situ concrete to be delivered to the bridge location for superstructure construction compared with Options 1 and 3, This will be delivered along the site corridor with un-inhibited access required along the site during pouring. However, it is anticipated that the superstructure could be poured in one continuous pour during a long working day.

Erectable/Buildability & Programme

Creation of the integral connections between the superstructure and substructures is easier to achieve than for Option 3.

From history and experience, achieving specified cover and finishes to the superstructure soffit are usually more challenging with this form of construction. Greater control on quality during construction is therefore required to achieve an acceptable final solution compared with Options 1 and 3.

Furthermore, the time taken to erect and dismantle falsework, as well as fix greater quantities of reinforcement, means that Option 4 would take considerably longer to construct than other options employing fabricated steel beams or precast prestressed concrete beams.

Safe to construct

The erection and dismantling of falsework to construct the superstructure involves considerably greater working at height than for Options 1 and 3.

The larger diameter and hence heavier reinforcement bars than those needed for the construction of the superstructures to Options 1 and 3 will require handling on site to fix them in position. The largest diameter bars are typically those in the top of the superstructure section in the hogging regions over the piers, and their weight and location in the section typically makes fixing these bars more difficult than others. Any need for shear links identified following detailed design calculations tend to further exacerbate the complexities of the reinforcement fixing, with the links needing to be tied off top and bottom prior to pouring. In addition, the weight of the reinforcement cage within the superstructure needs to be supported from the exposed soffit using appropriate cover blocks compliant with the specification and which need to be secured against displacement.

Larger volumes of in-situ concrete require placement in the superstructure over longer periods compared with Options 1 and 3, requiring longer periods of handling the equipment needed to pour concrete.

Unauthorised access to soffit

There are no bearings at the integral bankseat end supports, and hence no enclosures are required.

With little in the way of handholds, any risk of unauthorised access to the superstructure near the bankseat abutments is considered to be negligible.

Durability - Maintenance for future durability

With no bearings or structural steelwork to maintain or paint, a reinforced concrete superstructure provides a significant advantage over Option 1 in terms of future maintenance liability.

However, in-situ reinforced concrete superstructures constructed with site controls in place typically provide less durable solutions compared with precast, pre-stressed concrete beam solutions with factory controls in place, and so the maintenance liability for the superstructure elements (in terms of the likelihood of needing to carry out concrete repairs) is considered to be higher than Option 3.

Environment - Noise, local air quality, greenhouse gas emissions, land-take and transport

Option 4 requires a greater number of vehicle movements to deliver and remove falsework, formwork and reinforcement compared with Options 1 and 3. In addition, this structural form requires a greater number of vehicle movements along the site corridor to deliver in-situ concrete for the superstructure construction compared with Options 1 and 3.

Option 4 has a greater landtake and visual intrusion compared with Option 1 by virtue of its greater construction depth and longer tie-in lengths along the side road alignments. Option 4 has a similar impact to Option 3 for side roads with a straight grade vertical alignment, but a lower impact than Option 3 for crested side road vertical alignments.

The interruption of the haul road below the structure by the presence of falsework during the superstructure construction period may also adversely affect the highway network in the locality.

Comparative Construction Cost

The comparative construction cost of Option 4 is £538,000 in cut and £550,000 in fill.

Comparative Whole Life Cost

The comparative whole life cost of Option 4 is £538,000 in cut and £550,000 in fill.

6.5.8 OPTION 5 – c20m Single Span Steel Concrete Composite Multi Beam Superstructure

Description

Option 5 comprises:

- Single span steel concrete composite superstructure with parallel steel beams.
- Reinforced concrete deck end bankseats, currently assumed founded on spread footings above reinforced soil abutments for option comparison. Piled supports to the reinforced concrete deck end bankseats, linked via reinforced concrete columns sleeved through the reinforced soil abutments, could readily be accommodated.
- Superstructure fully integral with deck end bankseats, with no bearings.
- Deck end joint details would again likely comprise a simple saw cut joint through the surfacing.

Option 5 is illustrated in Figures 29 to 31 below.

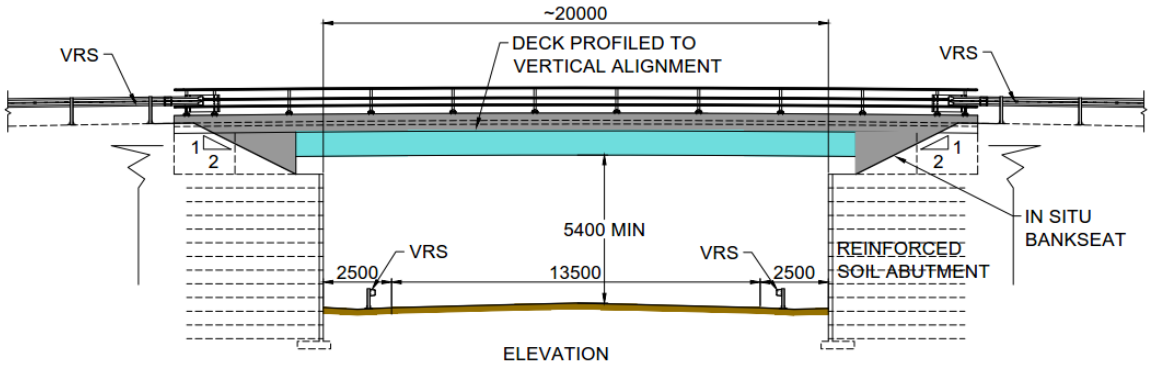


Figure 29 – Option 5 Elevation

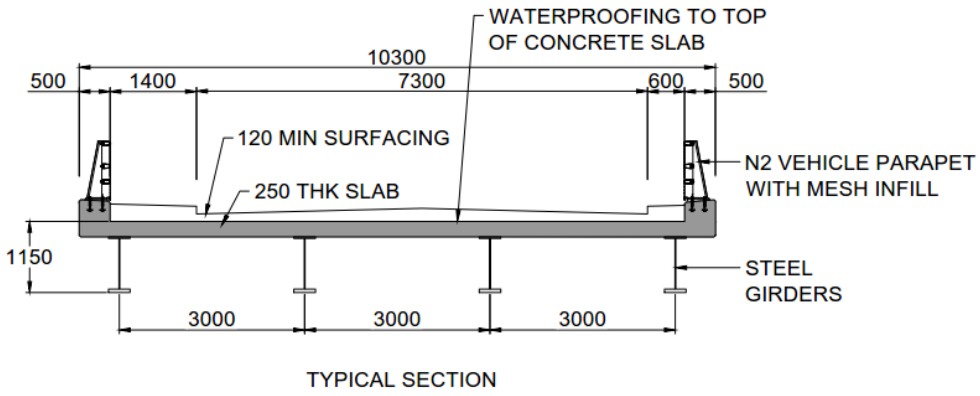


Figure 30 – Option 5 Deck Section

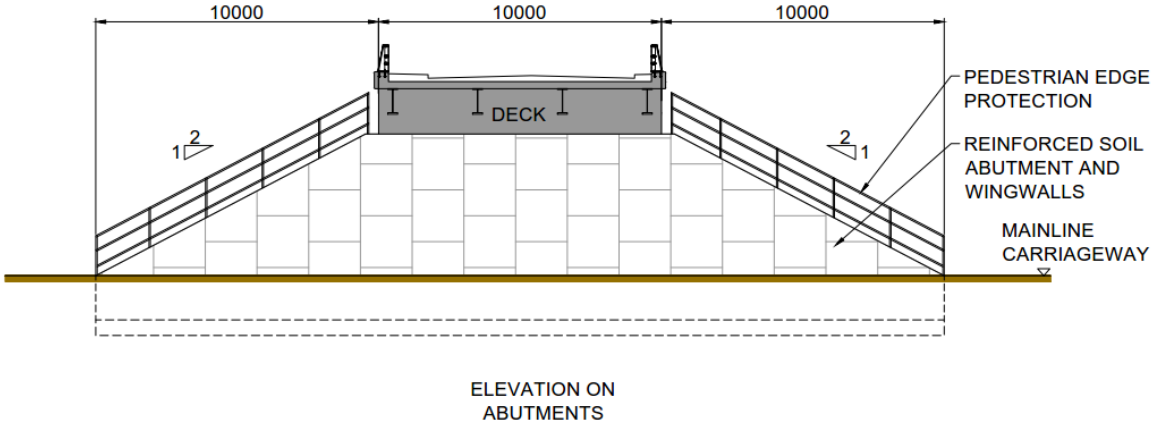


Figure 31 – Option 5 Abutment and Wingwall Elevation

Outline Construction Sequence

The outline construction sequence would be:

- Construct reinforced soil abutments and wingwalls as construction of approach embankments progresses. Monitor for settlement.
- Construct lower portion of reinforced concrete deck end bankseats to superstructure above reinforced soil abutment.
- Deliver steel beams to site and lay down. Assemble steel beams as braced pairs at ground level, attach edge protection. Note that with such short beam lengths, it may be possible to deliver the beams to site already connected as braced pairs.
- Lift all braced pairs of steel beams.
- Erect permanent formwork to form deck soffit between beam top flanges.
- Fix deck reinforcement, pour in-situ concrete deck and integral connection to deck end screens.
- Complete backfill to rear of deck end screens.
- Complete finishes – waterproofing, parapets, kerbs, surfacing, etc.

Aesthetics and Landscape Effects -Family of structures, Open aspect/aesthetics

The structural form provides a closed aspect, more appropriate to situations where side roads pass over the mainline on embankment fill. The closed appearance of the structure could be softened in elevation through the introduction of wingwalls aligned either parallel with the main line carriageway, or angled at approximately 45 degrees to the line of the abutments in plan.

The contrast between the painted steel beams and the reinforced concrete stringcourse to the deck elevations, the relatively slender deck, together with the ability to readily accommodate larger deck edge cantilevers than Option 7, all typically lead to the provision of an aesthetically superior structure compared with the other c20m span overbridge options.

Highway Alignment and Earthworks Balance – Impacts beyond the bridge location

Of the c20m span overbridge options, this structural form provides the least construction depth, and the use of steel allows the superstructure to be profiled in elevation to follow the vertical alignment of the side roads. It therefore has the least impact beyond the limits of the bridge site of the c20m span options, minimising the length of side road diversion and land-take needed to provide tie-ins.

Overall Construction Methodology and Approach and Safe by Design

Maintenance of haul route

This bridge form can readily be constructed without obstructing the haul route along the site, and is thereby aligned with the overall scheme philosophy. Of all of the options considered, Option 5 would be the quickest to erect and hence the least disruptive to the haul route.

Transportable

Fabricated steel beams are relatively lightweight, and can be delivered to site in short lengths and spliced on site prior to erection as required. Delivery to site as readily assembled braced pairs could allow erection directly from the delivery vehicle.

Erectable/Buildability & Programme

The bridge form is simple to construct, and is of familiar construction, meaning that erection and completion is usually rapid.

Careful and integrated design, checking, specification and construction processes are required in order to provide an appropriate reinforced soil abutment solution.

Safe to construct

The lifting of braced pairs of beams provides an inherently stable solution. Edge protection can be assembled at ground level prior to erection. Permanent formwork provides a closed soffit for safe working at height for all subsequent construction operations at height.

Simple, familiar, standard-type details all lend themselves to safe construction.

Unauthorised access to soffit

There are no bearings at the integral bankseat end supports, and hence no enclosures are required.

Despite the rural location, there is a perception that unauthorised access could be gained to the superstructure near the deck end bankseat abutments, which would have only a nominal 1m clearance to the top of the reinforced soil abutment. Unauthorised access below the deck soffit could be prevented through the use of a lockable gate at the front face of the bankseat.

Durability - Maintenance for future durability

A complete grit-blast and repaint of the structural steelwork will typically be required at approximately 25 year intervals. This activity will require traffic management on the A487 and the provision of enclosures around the superstructure steelwork for the grit-blast and repainting activities. In addition, a mid-term maintenance intervention will typically be required to address minor breakdown of the protective treatment system and ensure that the 25 year major maintenance cycle is achieved.

Environment - Noise, local air quality, greenhouse gas emissions, land-take and transport

Of all of the overbridge options, this structural form provides the fewest transport moves, one of the lowest landtakes and least visual intrusion associated with the low construction depth and earlier tie-ins along the side road alignments.

The ability to readily accommodate the haul road through the bridge construction site minimises the impact of traffic which may otherwise have to use the local highway network.

Comparative Construction Cost

The comparative construction cost of Option 5 is £417,000 in cut and £429,000 in fill.

Comparative Whole Life Cost

The comparative whole life cost of Option 5 is £473,000 in cut and £486,000 in fill.

6.5.9 OPTION 6 – c20m Single Span Steel Concrete Composite Ladder Deck Superstructure

Description

Option 6 comprises:

- Single span steel concrete composite ladder deck superstructure.
- Reinforced concrete deck end bankseats, currently assumed founded on spread footings above reinforced soil abutments. Piled supports to the reinforced concrete deck end bankseats, linked via reinforced concrete columns sleeved through the reinforced soil abutments, could readily be accommodated.
- Superstructure fully integral with deck end bankseats, with no bearings.
- Deck end joint details would again likely comprise a simple saw cut joint through the surfacing.

From discussion of Option 2 compared with Option 1, it has been concluded that ladder decks are inefficient for the c20m span range compared with multi-beam decks, and therefore Option 6 has not been considered further.

6.5.10 OPTION 7 – c20m Single Span Pre-cast Pre-stressed Concrete Beam Superstructure on Reinforced Soil Abutments

Description

Option 7 comprises:

- Single span pre-cast pre-stressed concrete beam superstructure.
- Reinforced concrete deck end bankseats, currently assumed founded on spread footings above reinforced soil abutments for option comparison. Piled supports to the reinforced concrete deck end bankseats, linked via reinforced concrete columns sleeved through the reinforced soil abutments, could readily be accommodated.
- Superstructure fully integral with deck end bankseats, with no bearings.
- Deck end joint details would again likely comprise a simple saw cut joint through the surfacing.

Option 7 is illustrated in Figures 32 to 34 below.

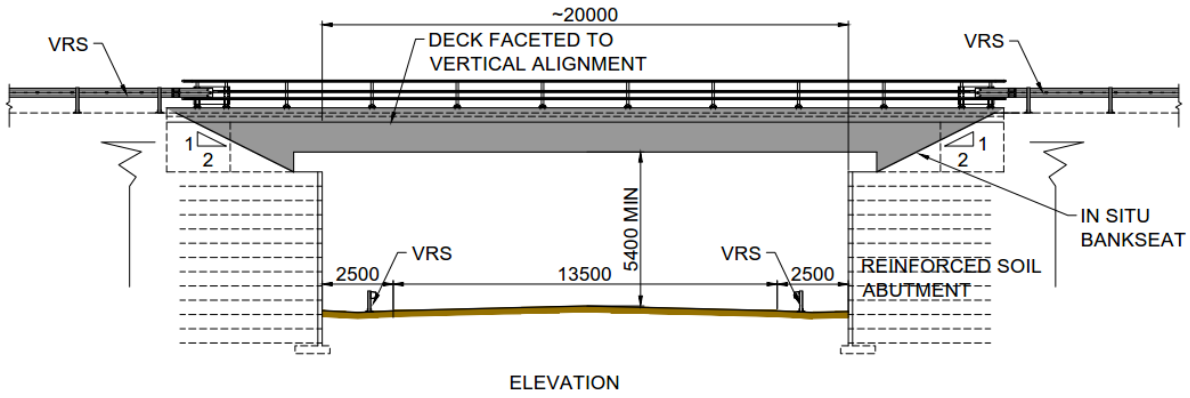


Figure 32 – Option 7 Elevation

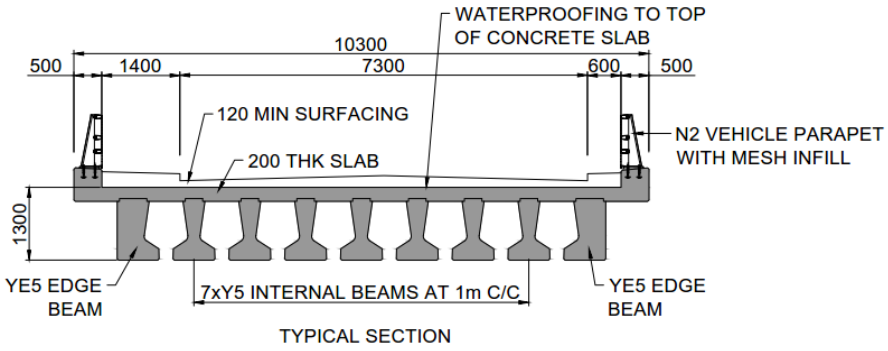


Figure 33 – Option 7 Deck Section

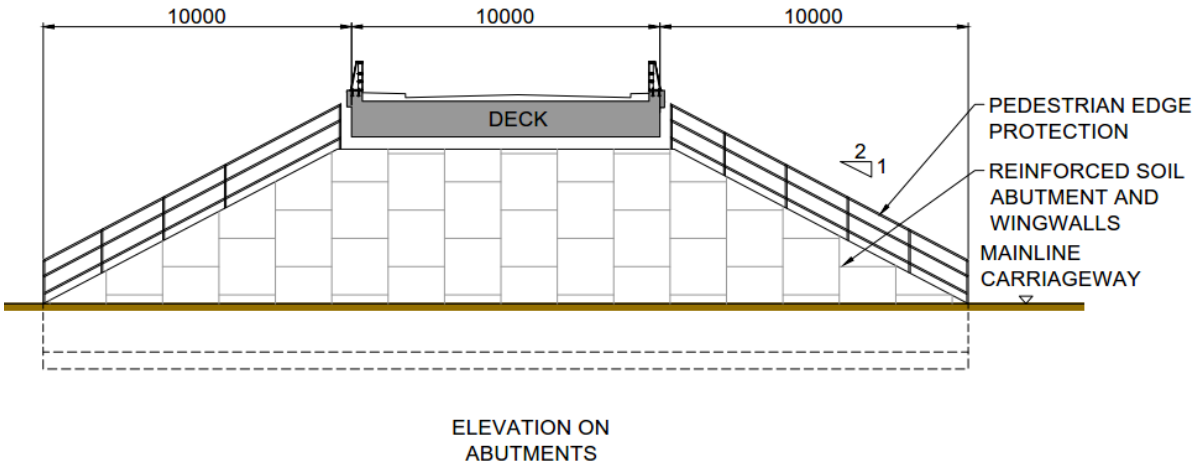


Figure 34 – Option 7 Abutment and Wingwall Elevation

Outline Construction Sequence

The outline construction sequence would be:

- Construct reinforced soil abutments and wingwalls as construction of approach embankments progresses. Monitor for settlement.
- Construct lower portion of reinforced concrete deck end bankseats to superstructure above reinforced soil abutment.
- Deliver pre-cast pre-stressed concrete beams to site, attach edge protection at ground level for edge beams, and lift into position on grout bed to bankseats.
- Erect permanent formwork to form deck soffit between beam top flanges.
- Fix deck reinforcement, pour in-situ concrete deck and integral connection to deck end screens.
- Complete backfill to rear of deck end screens.
- Complete finishes – waterproofing, parapets, kerbs, surfacing, etc.

Aesthetics and Landscape Effects -Family of structures, Open aspect/aesthetics

The structural form provides a closed aspect, more appropriate to situations where side roads pass over the mainline on embankment fill. The closed appearance of the structure could be softened in elevation through the introduction of wingwalls aligned either parallel with the main line carriageway, or angled at approximately 45 degrees to the line of the abutments in plan.

Pre-stressed concrete beams are typically almost straight in elevation following the application of all dead and superimposed dead load and following the loss of some pre-stress as a result of long term creep and shrinkage effects. Aesthetically, matching a single span comprising pre-stressed concrete beams to a side road alignment on a vertical curve would likely give rise to varying depth stringcourses in elevation, which is aesthetically undesirable. For aesthetics, then, the side road vertical curve would ideally be a straight grade across the bridge length in order to accommodate this form of structure.

The use of pre-cast pre-stressed concrete beams for a c20m span option results in a greater construction depth than Options 1 to 5 inclusive. With a small deck edge cantilever casting little shadow, with no contrast in colour between the concrete stringcourse and the concrete beam, and with a greater construction depth compared with Options 1 to 5, Option 7 will appear “heavier” than Options 1 to 5.

Highway Alignment and Earthworks Balance – Impacts beyond the bridge location

The construction depth is greater than Options 1 to 5 and the precast beams are ideally matched to a straight grade vertical side road alignment. Whilst both of these effects serve to increase the height of the embankment on the approaches to the bridge increasing the length of side road diversions and land-take needed to provide tie-ins compared with Options 1 to 5, the slightly adverse effects are mitigated by the opportunity to introduce vertical curvature beyond the limits of the shorter span length.

Overall Construction Methodology and Approach and Safe by Design

Maintenance of haul route

This bridge form can readily be constructed without obstructing the haul route along the site, and is thereby aligned with the overall scheme philosophy.

Transportable

Pre-cast concrete beams of approximately 23m length are relatively lightweight, and can be delivered to site.

Erectable/Buildability & Programme

The bridge form is simple to construct, and is of familiar construction, meaning that erection and completion is usually rapid.

Careful and integrated design, checking, specification and construction processes are required in order to provide an appropriate reinforced soil abutment solution.

Safe to construct

The lifting of edge beams with cantilever formwork in place to provide edge protection is typically inherently unstable during erection. Precast concrete stringcourses could be utilised in lieu of an in-situ stringcourse to mitigate such instability during erection. However, temporary works are typically required between all beams to stabilise them from over-turning during construction.

Permanent formwork provides a closed soffit for safe working at height for all subsequent construction operations at height.

Simple, familiar, standard-type details all lend themselves to safe construction.

Unauthorised access to soffit

There are no bearings at the integral bankseat end supports, and hence no enclosures are required.

With little in the way of handholds, any risk of unauthorised access to the superstructure near the bankseat abutments is considered to be negligible.

Durability - Maintenance for future durability

With no bearings or structural steelwork to maintain or paint, a concrete superstructure provides a significant advantage over Options 1, 5 and 6 in terms of future maintenance liability.

Environment - Noise, local air quality, greenhouse gas emissions, land-take and transport

The structural form for Option 7 requires a greater number of beams to be delivered to site compared with Option 5, but less than Options 1 to 4 by virtue of the single span configuration.

Option 7 has a greater landtake and visual intrusion compared with Options 1 and 5 by virtue of its greater construction depth, straight vertical alignment profile and longer tie-in lengths along the side road alignments.

The ability to readily accommodate the haul road through the bridge construction site minimises the impact of traffic which may otherwise have to use the local highway network.

Comparative Construction Cost

The comparative construction cost of Option 7 with reinforced soil substructures is £425,000 in cut and £438,000 in fill.

Comparative Whole Life Cost

The comparative whole life cost of Option 7 is £425,000 in cut and £438,000 in fill.

6.5.11 OPTION 7 Alternative – c20m Single Span Pre-cast Pre-stressed Concrete Beam Superstructure on Reinforced Concrete Abutments

Description

An alternative substructure arrangement for Option 7 could comprise in-situ reinforced concrete abutments made fully integral with the superstructure, in lieu of the reinforced soil substructures presented above.

The alternative arrangement is illustrated in Figures 35 to 37 below.

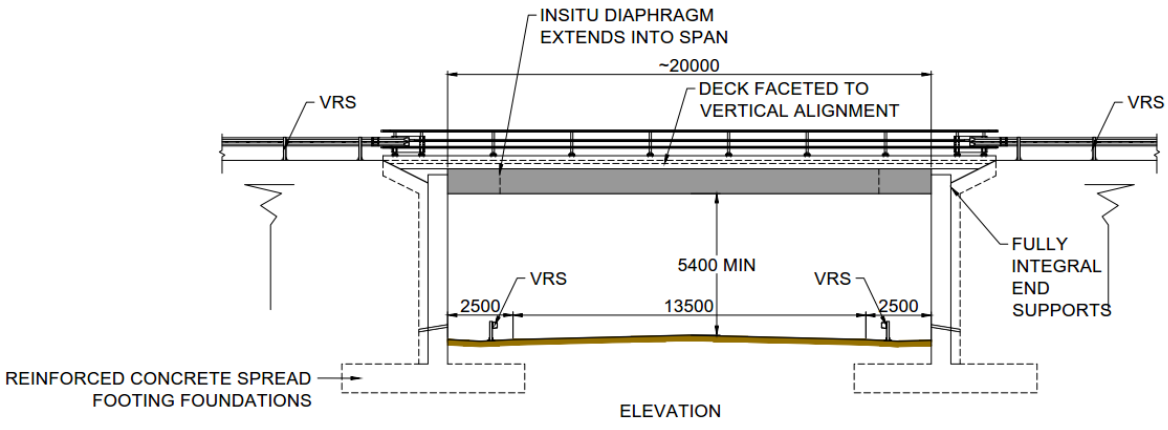


Figure 35 – Option 7 Alternative Elevation

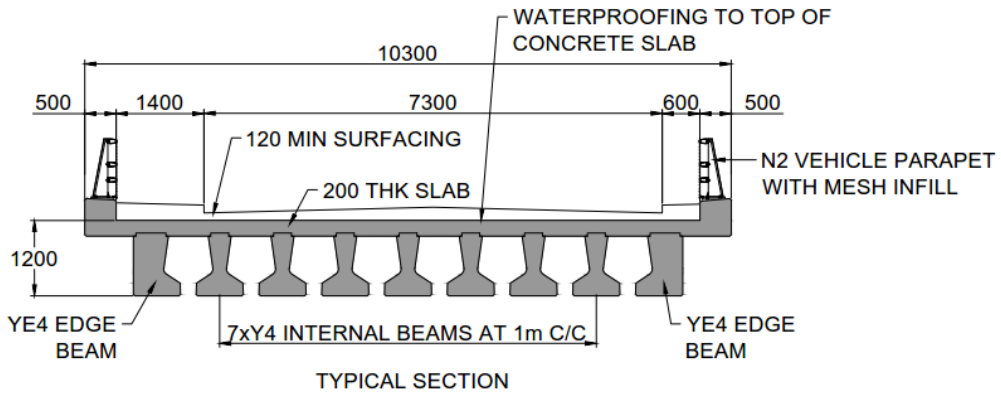


Figure 36 – Option 7 Alternative Deck Section

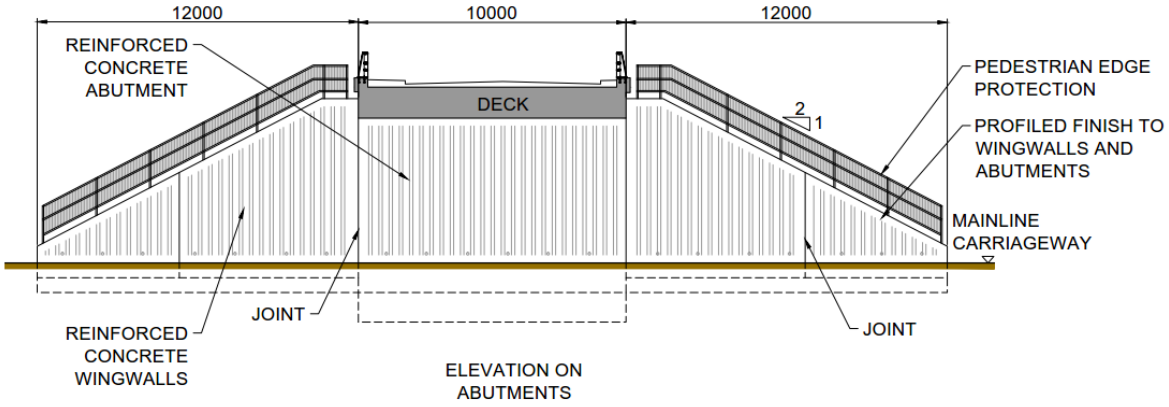


Figure 37 – Option 7 Alternative Abutment and Wingwall Elevation

Principal differences compared with the reinforced soil substructure solution are described below:

Overall Construction Methodology and Approach and Safe by Design

Erectable/Buildability & Programme

The introduction of in-situ reinforced concrete substructures would require an increased programme duration for construction of the bridge compared with reinforced soil substructures.

The issues of creating a fully integral connection between the deck and the abutments are similar to those described for the integral connections between the piers and superstructure for Option 3.

Environment - Noise, local air quality, greenhouse gas emissions, land-take and transport

Reinforced concrete substructures would require a greater number of deliveries of in-situ reinforced concrete along the site.

Comparative Construction Cost

The comparative construction cost of Option 7 with in-situ reinforced concrete substructures is £458,000 in cut and £471,000 in fill.

Comparative Whole Life Cost

The comparative whole life cost of Option 7 with in-situ reinforced concrete substructures is £458,000 in cut and £471,000 in fill.

6.5.12 OPTION 8 – c20m Single Span Reinforced Concrete Slab Superstructure

Description

Option 8 comprises:

- Single span reinforced concrete slab superstructure.
- Reinforced concrete deck end bankseats, currently assumed founded on spread footings above reinforced soil abutments. Piled supports to the reinforced concrete deck end bankseats, linked via reinforced concrete columns sleeved through the reinforced soil abutments, could readily be accommodated.
- Superstructure fully integral with deck end bankseats, with no bearings.
- Deck end joint details would again likely comprise a simple saw cut joint through the surfacing.

From feasibility costing of Option 4 compared with Option 1 to 3, it has been concluded that in-situ reinforced concrete decks are inefficient for the c20m simply supported span range compared with pre-stressed pre-cast concrete decks, and therefore Option 8 has not been considered further.

6.5.13 OPTION 9 – c30m Single Span Steel Concrete Composite Multi Beam Superstructure

Description

Option 9 comprises:

- Single c30m span steel concrete composite superstructure with parallel steel beams.
- Reinforced concrete abutments currently assumed founded on spread footings for option comparison. Piled supports to the abutments could readily be accommodated.
- Superstructure fully integral with abutments with no bearings.
- Deck end joint details would again likely comprise a simple saw cut joint through the surfacing.

Option 9 is illustrated in Figures 38 and 39 below.

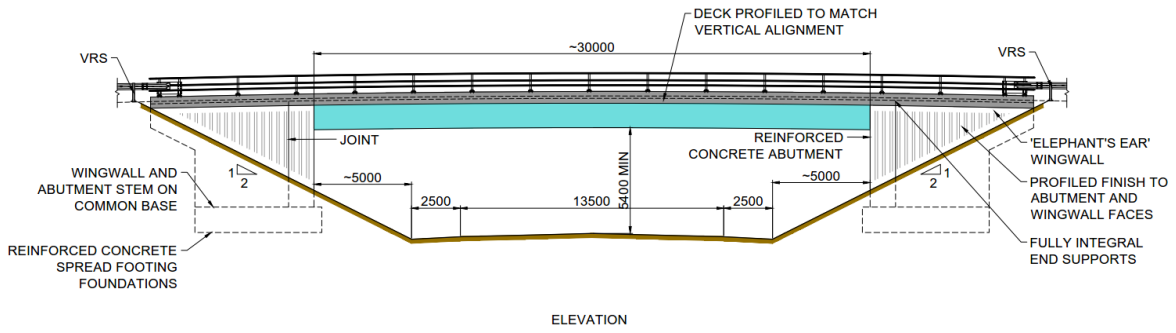


Figure 38 – Option 9 Elevation

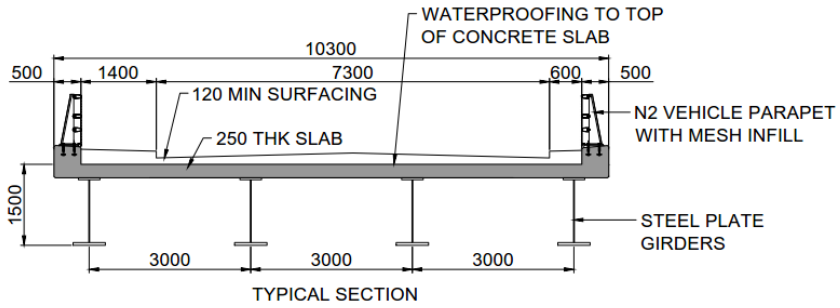


Figure 39 – Option 9 Deck Section

Outline Construction Sequence

The outline construction sequence would be:

- Excavate into side slopes. Construct in-situ reinforced concrete abutments and wingwalls.
- Deliver steel beams to site and lay down. Assemble steel beams as braced pairs at ground level, attach edge protection.
- Lift all braced pairs of steel beams.
- Erect permanent formwork to form deck soffit between beam top flanges.
- Fix deck reinforcement, pour in-situ concrete deck and integral connection to abutments.
- Complete backfill to rear of abutments and Wingwalls.
- Complete finishes – waterproofing, parapets, kerbs, surfacing, etc.

Aesthetics and Landscape Effects -Family of structures, Open aspect/aesthetics

The structural form provides a more open aspect than the single c20m span Options 5 to 8, but one which is not as open as the 3 span Options 1 to 4.

The appearance of the structure could be softened in elevation through the introduction of wingwalls aligned either parallel with the main line carriageway, or angled at approximately 45 degrees to the line of the abutments in plan.

The increased superstructure construction depth required to accommodate the greater span length will provide a "heavier" aesthetic appearance than the equivalent steel concrete composite solutions for Options 1 and 5.

Highway Alignment and Earthworks Balance – Impacts beyond the bridge location

Of the c30m span overbridge options, this structural form provides the least construction depth, and the use of steel allows the superstructure to be profiled in elevation to follow the vertical alignment of the side roads. It therefore has the least impact beyond the limits of the bridge site of the c30m span options, but a greater impact on the length of side road diversion and land-take needed to provide tie-ins compared with Options 1 to 8.

Overall Construction Methodology and Approach and Safe by Design

Maintenance of haul route

This bridge form can readily be constructed without obstructing the haul route along the site, and is thereby aligned with the overall scheme philosophy. The possible need to introduce a site splice within the span means that this option, whilst quick to erect, may require more time to construct than Option 5.

Transportable

Fabricated steel beams are relatively lightweight, and can be delivered to site in short lengths and spliced on site prior to erection as required. Delivery to site as readily assembled braced pairs could allow erection directly from the delivery vehicle, although these would be of significant longer length than Option 5.

Erectable/Buildability & Programme

The bridge form is simple to construct, and is of familiar construction, meaning that erection and completion is usually rapid.

In-situ reinforced concrete substructures would require an increased programme duration for construction of the bridge compared with reinforced soil substructures, which may afford an alternative.

The issues of creating a fully integral connection between the deck and the abutments are similar to those described for the integral connections between the piers and superstructure for Option 3, albeit more readily achievable in steel as opposed to pre-stressed concrete.

Safe to construct

The lifting of braced pairs of beams provides an inherently stable solution. Edge protection can be assembled at ground level prior to erection. Permanent formwork provides a closed soffit for safe working at height for all subsequent construction operations at height.

Simple, familiar, standard-type details all lend themselves to safe construction.

Unauthorised access to soffit

There are no bearings at the integral bankseat end supports, and hence no enclosures are required.

This option provides greater than 3m headroom above the side slopes, thereby precluding unauthorised access to the soffit.

Durability - Maintenance for future durability

A complete grit-blast and repaint of the structural steelwork will typically be required at approximately 25 year intervals. This activity will require traffic management on the A487 and the provision of enclosures around the superstructure steelwork for the grit-blast and repainting activities. In addition, a mid-term maintenance intervention will typically be required to address minor breakdown of the protective treatment system and ensure that the 25 year major maintenance cycle is achieved.

Environment - Noise, local air quality, greenhouse gas emissions, land-take and transport

Landtake and visual intrusion associated with the greater construction depth is similar to Options 10 and 11, and greater than Options 1 to 8.

The ability to readily accommodate the haul road through the bridge construction site minimises the impact of traffic which may otherwise have to use the local highway network.

Comparative Construction Cost

The comparative construction cost of Option 9 is £504,000 in cut and £516,000 in fill.

Comparative Whole Life Cost

The comparative whole life cost of Option 9 is £587,000 in cut and £600,000 in fill.

6.5.14 OPTION 10 – c30m Single Span Steel Concrete Composite Ladder Deck Superstructure

Description

Option 10 is similar to Option 9, except it comprises:

- Single span steel concrete composite ladder deck superstructure in lieu of a multi-beam superstructure. Note that a similar depth to the multi-beam option with increased element thicknesses has been selected to minimise impacts beyond the bridge site.

Option 10 is illustrated in Figures 40 and 41 below.

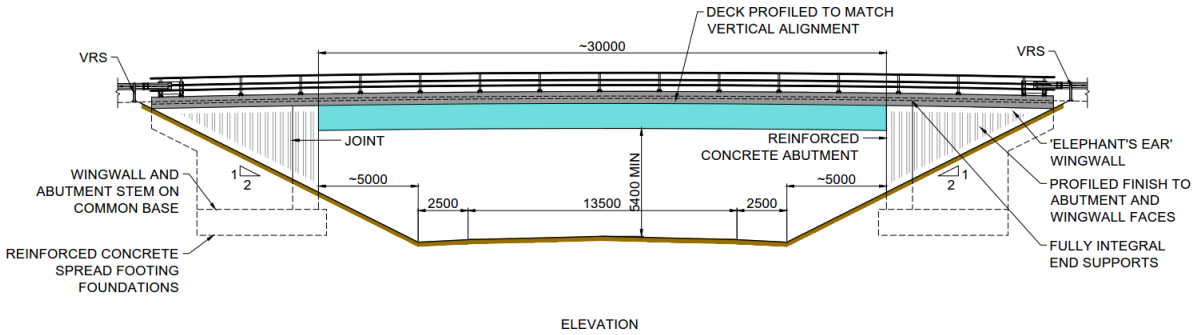


Figure 40 – Option 10 Deck Section

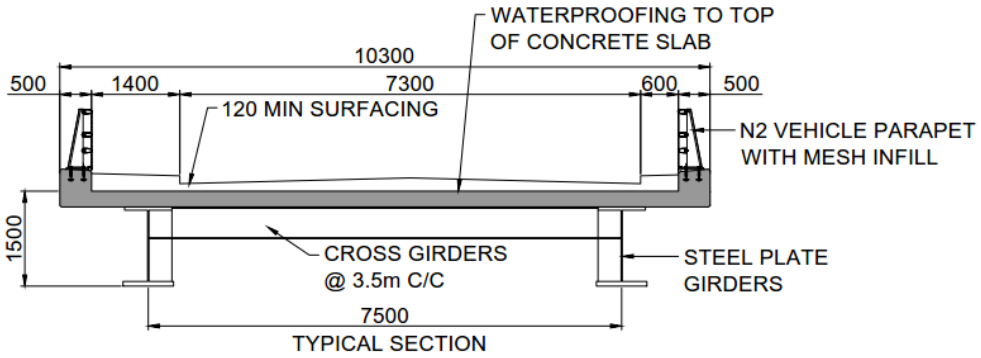


Figure 41 – Option 10 Elevation

Comparative Construction Cost

The comparative construction cost of Option 10 is £515,000 in cut and £540,000 in fill.

Comparative Whole Life Cost

The comparative whole life cost of Option 10 is £598,000 in cut and £623,000 in fill.

6.5.15 OPTION 11 – c30m Single Span Pre-cast Pre-stressed Concrete Beam Superstructure

Description

Option 11 comprises:

- Single c30m span pre-cast pre-stressed concrete beam superstructure.
- Reinforced concrete abutments currently assumed founded on spread footings for option comparison. Piled supports to the abutments could readily be accommodated.
- Superstructure fully integral with abutments with no bearings.
- Deck end joint details would again likely comprise a simple saw cut joint through the surfacing.

Option 11 is illustrated in Figures 42 and 43 below.

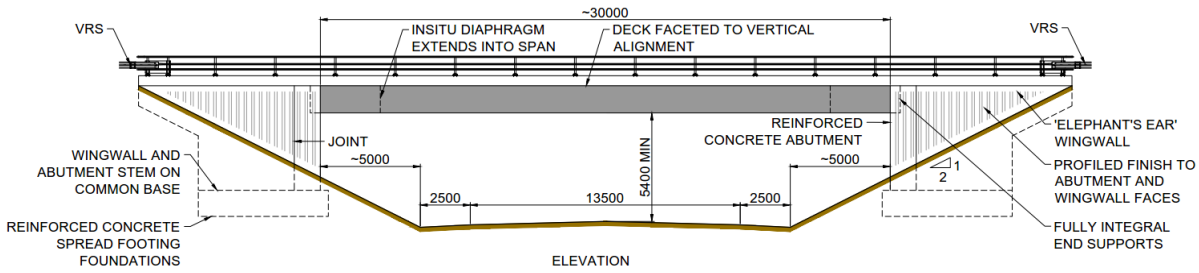


Figure 42 – Option 11 Elevation

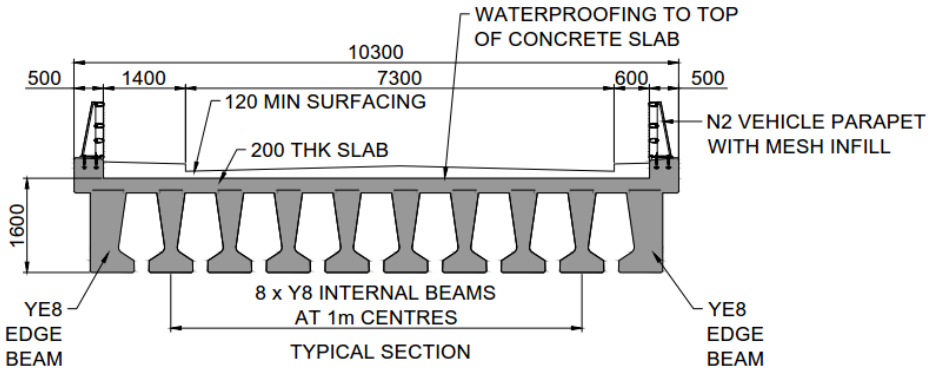


Figure 43 – Option 11 Deck Section

Outline Construction Sequence

The outline construction sequence would be:

- Excavate into side slopes. Construct in-situ reinforced concrete abutments and wingwalls.
- Deliver pre-cast pre-stressed concrete beams to site, attach edge protection at ground level for edge beams, and lift into position on grout bed to bankseats.
- Brace beams to provide temporary stability.
- Erect permanent formwork to form deck soffit between beam top flanges.
- Fix deck reinforcement, pour in-situ concrete deck and integral connection to abutments.
- Complete backfill to abutments.
- Complete finishes – waterproofing, parapets, kerbs, surfacing, etc.

Aesthetics and Landscape Effects -Family of structures, Open aspect/aesthetics

As with Options 9 and 10, the structural form provides a more open aspect than the single c20m span Options 5 to 8, but one which is not as open as the 3 span Options 1 to 4. Again, the appearance of the structure could be softened in elevation through the introduction of wingwalls aligned either parallel with the main line carriageway, or angled at approximately 45 degrees to the line of the abutments in plan.

Again, the straight elevation of pre-stressed concrete beams are typically almost straight in elevation, and thus for aesthetics, the side road vertical curve would ideally

be a straight grade over the length of the bridge superstructure to accommodate this form of structure.

The increased superstructure construction depth required to accommodate the greater span length will provide a “heavier” aesthetic appearance than the equivalent pre-stressed concrete beam solutions for Options 3 and 7.

Highway Alignment and Earthworks Balance – Impacts beyond the bridge location

The construction depth is the greatest of all Options 1 to 11 and the precast beams are ideally matched to a straight grade vertical side road alignment. Both of these effects serve to increase the height of the embankment on the approaches to the bridge increasing the length of side road diversions and land-take needed to provide tie-ins for Option 11 compared with all other options.

Overall Construction Methodology and Approach and Safe by Design

Maintenance of haul route

This bridge form can readily be constructed without obstructing the haul route along the site, and is thereby aligned with the overall scheme philosophy.

Transportable

Pre-cast concrete beams of approximately 31m length are relatively lightweight, and it is considered likely that they can be delivered to site. However, unlike steel solutions, there is no opportunity to break the beams down into smaller units should delivery prove challenging, and the risk would need to be mitigated through delivery route selection and potential removal of street furniture to facilitate transportation.

Erectable/Buildability & Programme

The bridge form is simple to construct, and is of familiar construction, meaning that erection and completion is usually rapid.

Safe to construct

The lifting of edge beams with cantilever formwork in place to provide edge protection is typically inherently unstable during erection. Precast concrete stringcourses could be utilised in lieu of an in-situ stringcourse to mitigate such instability during erection. However, temporary works are typically required between all beams to stabilise them from over-turning during construction.

Permanent formwork provides a closed soffit for safe working at height for all subsequent construction operations at height.

Simple, familiar, standard-type details all lend themselves to safe construction.

Unauthorised access to soffit

There are no bearings at the integral bankseat end supports, and hence no enclosures are required.

This option provides greater than 3m headroom above the side slopes, thereby precluding unauthorised access to the soffit.

Durability - Maintenance for future durability

With no bearings or structural steelwork to maintain or paint, a concrete superstructure provides a significant advantage over Options 1, 5, 6, 9 and 10 in terms of future maintenance liability.

Environment - Noise, local air quality, greenhouse gas emissions, land-take and transport

The structural form for Option 11 requires a greater number of beams to be delivered to site compared with Options 5, 9 and 10, but less than Options 1 to 4 by virtue of the single span configuration.

Option 11 has the greater landtake and visual intrusion compared with all overbridge options by virtue of its greater construction depth, straight vertical alignment profile and longer tie-in lengths along the side road alignments.

The ability to readily accommodate the haul road through the bridge construction site minimises the impact of traffic which may otherwise have to use the local highway network.

Comparative Construction Cost

The comparative construction cost of Option 11 is £492,000 in cut and £517,000 in fill.

Comparative Whole Life Cost

The comparative whole life cost of Option 11 is £492,000 in cut and £517,000 in fill.

6.5.16 OPTION 12 – c30m Single Span Reinforced Concrete Slab Superstructure

Description

Option 12, comprising a c30m single span reinforced concrete slab superstructure, is uneconomic at this span range and has thus not been considered further.

6.5.17 Summary of Comparative Construction Depths

A summary of comparative construction depth is presented below. Principal element sizes have typically been determined from available look-up tables and/or manufacturers' data sheets, blended with experience of similar structural forms on other highway schemes, in order to provide a basis for comparison, and would be subject to refinement through preliminary and detailed design.

	Superstructure Materials			
Span arrangement	**Steel concrete composite multi-beam deck**	**Steel concrete composite ladder deck**	**Pre-cast pre-stressed concrete beam deck**	**In-situ reinforced concrete deck**
3 span superstructure	Option 1 1000mm	Option 2 1175mm	Option 3 1200mm	Option 4 1250mm
c.20m single span superstructure (Reinforced Earth Substructures)	Option 5 1150mm	Option 6 N/A	Option 7 1300mm	Option 8 N/A
c.30m single span superstructure	Option 9 1500mm	Option 10 1500mm	Option 11 1600mm	Option 12 N/A

Table - Comparative Superstructure Construction Depths

6.5.18 Summary of Comparative Capital Works Costs for Generic Overbridge options

A summary of the comparative capital works costs for the generic overbridge options in cut and fill situations is presented in the table below.

	Superstructure Materials			
Span arrangement	**Steel concrete composite multi-beam deck**	**Steel concrete composite ladder deck**	**Pre-cast pre-stressed concrete beam deck**	**In-situ reinforced concrete deck**
3 span superstructure	**Option 1**	**Option 2**	**Option 3**	**Option 4**
Capital Cost in Cut	£431,000	N/A	£494,000	£538,000
Capital Cost in fill	£431,000	N/A	£519,000	£550,000
c.20m single span superstructure Reinforced Soil abutments (wingwalls in line with A487)	**Option 5**	**Option 6**	**Option 7**	**Option 8**
Capital Cost in Cut	£417,000	N/A	£425,000	N/A
Capital Cost in fill	£429,000	N/A	£438,000	N/A
Reinforced Concrete abutments (wingwalls in line with A487)				
Capital Cost in Cut	£432,000	N/A	£458,000	N/A
Capital Cost in fill	£444,000	N/A	£471,000	N/A
c.30m single span superstructure	**Option 9**	**Option 10**	**Option 11**	**Option 12**
Capital Cost in Cut	£504,000	£515,000	£492,000	N/A
Capital Cost in fill	£516,000	£540,000	£517,000	N/A

Table – Summary of comparative capital works costs for generic overbridge options

6.5.19 Summary of Comparative Whole Life Costs for Generic Overbridge options

A summary of the comparative whole life costs for the generic overbridge options in cut and fill situations is presented in the table below.

	Superstructure Materials			
Span arrangement	**Steel concrete composite multi-beam deck**	**Steel concrete composite ladder deck**	**Pre-cast pre-stressed concrete beam deck**	**In-situ reinforced concrete deck**
3 span superstructure	**Option 1**	**Option 2**	**Option 3**	**Option 4**
Whole Life Cost in Cut	£523,000	N/A	£494,000	£538,000
Whole Life Cost in fill	£523,000	N/A	£519,000	£550,000
c.20m single span superstructure Reinforced Soil abutments (wingwalls in line with A487)	**Option 5**	**Option 6**	**Option 7**	**Option 8**
Whole Life Cost in Cut	£473,000	N/A	£425,000	N/A
Whole Life Cost in fill	£486,000	N/A	£438,000	N/A
Reinforced Concrete abutments (wingwalls in line with A487)				
Whole Life Cost in Cut	£488,000	N/A	£458,000	N/A
Whole Life Cost in fill	£501,000	N/A	£471,000	N/A
c.30m single span superstructure	**Option 9**	**Option 10**	**Option 11**	**Option 12**
Whole Life Cost in Cut	£587,000	£598,000	£492,000	N/A
Whole Life Cost in fill	£600,000	£623,000	£517,000	N/A

Table – Summary of comparative whole life costs for generic overbridge options

6.5.20 Summary of Context for Structures and Other Factors Affecting Choice for Generic Overbridge options

A summary of the benefits and dis-benefits of each of the generic overbridge options reviewed against the Context for Structures and Other Factors Affecting Choice identified in Sections 4 and 5, respectively, above and excluding reference to costs, is presented in a series of tables below.

Whilst potentially subjective, and acknowledged as un-weighted, a relative (within the context of the twelve options) good/fair/poor (GFP) relative rating has been provided against the assessment criteria for each option, and these ratings have then been used to provide a visual colour comparative summary of the viable options.

OPTION 1 - 3 SPAN STEEL CONCRETE COMPOSITE MULTI BEAM SUPERSTRUCTURE				
	CRITERIA	**BENEFIT**	**DISBENEFIT**	**GFP**
Aesthetics and Landscape Effects	Family of structures	Family of structures achievable.		G
	Open aspect/aesthetics	Open aspect provided.		G
Highway Alignment and Earthworks Balance	Impacts beyond the bridge location	Minimum construction depth provided, minimises side slopes and length of side road tie ins. Can follow side road vertical alignment (crest curve).		G
Overall Construction Methodology and Approach and Safe by Design	Maintenance of haul route	Keeps haul route unobstructed – aligns with overall scheme philosophy.		G
	Transportable	Steel girders can be delivered in shorter lengths and site spliced.		G
	Erectable/Buildability & Programme	Lightweight. Steel girders lifted in braced pairs, “Paraslim” installed on edge beam. Simple to construct, familiar construction, inherently stable.		G
	Safe to construct	“Paraslim” and GRP formwork provides closed soffit for safe working at height for constructing composite deck slab.		G
	Unauthorised access to soffit.		3m headroom and bankseats difficult to achieve (risk of perception of unauthorised access).	F
Durability	Maintenance for future durability		Maintenance of protective treatment system required. Maintenance of bearings required.	F
Environment	Noise, local air quality, greenhouse gas emissions, land-take and transport	Fewest transport movements, lowest land-take, achieves tie ins earlier along side roads, less visually intrusive.		G

OPTION 3 - 3 SPAN PRE-CAST PRE-STRESSED CONCRETE BEAM SUPERSTRUCTURE				
	CRITERIA	**BENEFIT**	**DISBENEFIT**	**GFP**
Aesthetics and Landscape Effects	Family of structures	Family of structures achievable.		G
	Open aspect/aesthetics	Open aspect provided.	Facetted soffit for crest curve structures gives awkward aesthetic appearance.	F
Highway Alignment and Earthworks Balance	Impacts beyond the bridge location		Greater construction depths compared with steel concrete composite alternative, greater earthworks to approaches. May need consideration of SFZ at crossheads.	F
Overall Construction Methodology and Approach and Safe by Design	Maintenance of haul route	Keeps haul route unobstructed – aligns with overall scheme philosophy.		G
	Transportable		Longer transport lengths than steel alternative – psc beams cannot be broken into smaller length units.	F
	Erectable/Buildability & Programme		Heavier lift weights, larger craneage. Possible temporary stability of beams (with “Paraslim” attached). More difficult and time consuming construction – more awkward details, especially at piers. Integral piers results in larger foundations for piers.	F
	Safe to construct	“Paraslim” and GRP formwork provides closed soffit safe working at height for constructing composite deck slab.	Potential for more working at height providing continuity at piers compared with steel alternatives.	F
	Unauthorised access to soffit.	Superstructure less accessible to the public.		G
Durability	Maintenance for future durability	Fully integral – no bearings, no maintenance painting.		G
Environment	Noise, local air quality, greenhouse gas emissions, land-take and transport		Increased transport movements, increased land-take.	F

OPTION 4 - 3 SPAN IN-SITU REINFORCED CONCRETE SLAB SUPERSTRUCTURE				
	CRITERIA	**BENEFIT**	**DISBENEFIT**	**GFP**
Aesthetics and Landscape Effects	Family of structures	Family of structures achievable.		G
	Open aspect/aesthetics	Open aspect provided.		G
Highway Alignment and Earthworks Balance	Impacts beyond the bridge location	Can follow side road vertical alignment (crest curve).	Increased construction depth provided, increased length of side road tie in.	F
Overall Construction Methodology and Approach and Safe by Design	Maintenance of haul route		Greater disruption/interruption to haul road – falsework erection, pour, cure times to strike soffit formwork, dismantling of falsework.	P
	Transportable	No larger components to be delivered.		G
	Erectable/Buildability & Programme		Casting at ground level and top down construction typically not appropriate in fill situations. More works on site than in controlled factory conditions compared with steel or precast options. Greater risk of poorer finishes associated with greater area of site formwork, fixing of reinforcement (particularly to deck soffit), in situ pouring – skilled site labour required. Heavier construction and integral piers leading to larger foundations.	F
	Safe to construct		More work at height – falsework erection and dismantling – with greater risks to health and safety.	F
	Unauthorised access to soffit.	Superstructure less accessible to the public.		G
Durability	Maintenance for future durability	Fully integral – no bearings, no painting.		G
Environment	Noise, local air quality, greenhouse gas emissions, land-take and transport		More vehicle movements on existing roads to deliver concrete, greater earthworks to approaches, increased land-take, more visually intrusive.	F

OPTION 5 – C.20M SINGLE SPAN STEEL CONCRETE COMPOSITE MULTI BEAM SUPERSTRUCTURE				
	CRITERIA	**BENEFIT**	**DISBENEFIT**	**GFP**
Aesthetics and Landscape Effects	Family of structures	Family of structures achievable.		G
	Open aspect/aesthetics		Closed aspect compared with 3-span alternative. Wing walls and abutment elevations visually more dominant than 3-span alternative.	F
Highway Alignment and Earthworks Balance	Impacts beyond the bridge location	Can follow side road vertical alignment (crest curve).	Greater construction depths compared with 3-span steel concrete composite alternative, greater earthworks to approaches, tie ins achieved later along side roads.	F
Overall Construction Methodology and Approach and Safe by Design	Maintenance of haul route	Keeps haul route unobstructed – aligns with overall scheme philosophy.		G
	Transportable	Steel girders can be delivered in shorter lengths and site spliced.		G
	Erectable/Buildability & Programme	Lightweight. Steel girders lifted in braced pairs, “Paraslim” installed on edge beam. Simple and quick to construct, familiar construction, inherently stable.	Reinforced soil abutments require careful and integrated design, check and construction to provide durable low maintenance solution.	F
	Safe to construct	“Paraslim” and GRP formwork provides closed soffit safe working at height for constructing composite deck slab. Reinforced soil substructures require less work at height & manual handling c.f. RC substructures.		G
	Unauthorised access to soffit.	Superstructure inaccessible to public.		G
Durability	Maintenance for future durability	No bearings required.	Maintenance of protective treatment system required.	F
Environment	Noise, local air quality, greenhouse gas emissions, land-take and transport		More visually intrusive. Slightly greater land take than 3 span equivalent.	F

OPTION 7 – C.20M SINGLE SPAN PRE-CAST PRE-STRESSED CONCRETE BEAM SUPERSTRUCTURE – REINFORCED SOIL SUBSTRUCTURES				
	CRITERIA	**BENEFIT**	**DISBENEFIT**	**GFP**
Aesthetics and Landscape Effects	Family of structures	Family of structures achievable.		G
	Open aspect/aesthetics		Semi-open aspect compared with 3-span alternative. Wing walls and abutment elevations visually more dominant than 3-span alternative.	F
Highway Alignment and Earthworks Balance	Impacts beyond the bridge location		Greater construction depths compared steel alternatives, greater earthworks to approaches, tie ins achieved later along side roads. Facetted soffit for crest curve structure. Gives awkward aesthetic appearance on crest curves.	F
Overall Construction Methodology and Approach and Safe by Design	Maintenance of haul route	Keeps haul route unobstructed – aligns with overall scheme philosophy.		G
	Transportable		Longer transport lengths than steel alternatives – psc beams cannot be broken into smaller lengths.	F
	Erectable/Buildability & Programme	Simple to construct, familiar construction.	Heavier lift weights, larger craneage. Possible temporary beam instability with “Paraslim” attached. Reinforced soil abutments require careful and integrated design, check and construction to provide durable low maintenance solution.	F
	Safe to construct	“Paraslim” and GRP formwork provides closed soffit safe working at height for constructing composite deck slab. Reinforced soil substructures require less work at height & manual handling c.f. RC substructures.		G
	Unauthorised access to soffit.	Superstructure inaccessible to public.		G
Durability	Maintenance for future durability	Fully integral – no bearings, no painting.		G
Environment	Noise, local air quality, greenhouse gas emissions, land-take and transport		More visually intrusive. Slightly greater land take than 3 span equivalent.	F

OPTION 7 – C.20M SINGLE SPAN PRE-CAST PRE-STRESSED CONCRETE BEAM SUPERSTRUCTURE – REINFORCED CONCRETE SUBSTRUCTURES				
	CRITERIA	**BENEFIT**	**DISBENEFIT**	**GFP**
Aesthetics and Landscape Effects	Family of structures	Family of structures achievable.		G
	Open aspect/aesthetics		Semi-open aspect compared with 3-span alternative. Wing walls and abutment elevations visually more dominant than 3-span alternative.	F
Highway Alignment and Earthworks Balance	Impacts beyond the bridge location		Greater construction depths compared steel alternatives, greater earthworks to approaches, tie ins achieved later along side roads. Facetted soffit for crest curve structure. Gives awkward aesthetic appearance on crest curves.	F
Overall Construction Methodology and Approach and Safe by Design	Maintenance of haul route	Keeps haul route unobstructed – aligns with overall scheme philosophy.		G
	Transportable		Longer transport lengths than steel alternatives – psc beams cannot be broken into smaller lengths.	F
	Erectable/Buildability & Programme	Simple to construct, familiar construction.	Heavier lift weights, larger craneage. Possible temporary beam instability with “Paraslim” attached. Relatively large height integral abutments typically require upper bound limit to ϕ’ for backfill material to limit earth pressure effects, can lead to difficult yin sourcing appropriate backfill from site won material.	F
	Safe to construct	“Paraslim” and GRP formwork provides closed soffit safe working at height for constructing composite deck slab.		G
	Unauthorised access to soffit.	Superstructure inaccessible to public.		G
Durability	Maintenance for future durability	Fully integral – no bearings, no painting.		G
Environment	Noise, local air quality, greenhouse gas emissions, land-take and transport		More visually intrusive. Greater landtake. Slightly greater land take than 3 span equivalent.	F

OPTION 9 – C.30M SINGLE SPAN STEEL CONCRETE COMPOSITE MULTI BEAM SUPERSTRUCTURE				
	CRITERIA	**BENEFIT**	**DISBENEFIT**	**GFP**
Aesthetics and Landscape Effects	Family of structures	Family of structures achievable.		G
	Open aspect/aesthetics		Semi-open aspect compared with 3-span alternative. Wing walls and abutment elevations visually more dominant than 3-span alternative.	F
Highway Alignment and Earthworks Balance	Impacts beyond the bridge location	Can follow side road vertical alignment (crest curve).	Greater construction depths compared with 3-span steel concrete composite alternative, greater earthworks to approaches, tie ins achieved later along side roads.	F
Overall Construction Methodology and Approach and Safe by Design	Maintenance of haul route	Keeps haul route unobstructed – aligns with overall scheme philosophy.		G
	Transportable	Steel girders can be delivered in shorter lengths and site spliced.		G
	Erectable/Buildability & Programme	Lightweight. Steel girders lifted in braced pairs, “Paraslim” installed on edge beam. Simple to construct, familiar construction, inherently stable.	Relatively large height integral abutments typically require upper bound limit to ϕ’ for backfill material to limit earth pressure effects, can lead to difficult yin sourcing appropriate backfill from site won material.	F
	Safe to construct	“Paraslim” and GRP formwork provides closed soffit safe working at height for constructing composite deck slab.		G
	Unauthorised access to soffit.	Superstructure inaccessible to public.		G
Durability	Maintenance for future durability	No bearings required.	Maintenance of protective treatment system required.	F
Environment	Noise, local air quality, greenhouse gas emissions, land-take and transport		More visually intrusive. Greater land take.	F

OPTION 10 – C.30M SINGLE SPAN STEEL CONCRETE COMPOSITE LADDER DECK SUPERSTRUCTURE				
	CRITERIA	**BENEFIT**	**DISBENEFIT**	**GFP**
Aesthetics and Landscape Effects	Family of structures	Family of structures achievable.		G
	Open aspect/aesthetics		Semi-open aspect compared with 3-span alternative. Wing walls and abutment elevations visually more dominant than 3-span alternative.	F
Highway Alignment and Earthworks Balance	Impacts beyond the bridge location	Can follow side road vertical alignment (crest curve).	Greater construction depths compared with 3-span steel concrete composite alternative, greater earthworks to approaches, tie ins achieved later along side roads.	F
Overall Construction Methodology and Approach and Safe by Design	Maintenance of haul route	Keeps haul route unobstructed – aligns with overall scheme philosophy.		G
	Transportable	Steel girders can be delivered in shorter lengths and site spliced.		G
	Erectable/Buildability & Programme	Lightweight. Steel girders lifted in braced pairs, “Paraslim” installed on edge beam. Familiar construction.	Potential for heavier crane lift if erected with cross griders. Relatively large height integral abutments typically require upper bound limit to ϕ’ for backfill material to limit earth pressure effects, can lead to difficult yin sourcing appropriate backfill from site won material.	F
	Safe to construct	“Paraslim” and GRP formwork provides closed soffit safe working at height for constructing composite deck slab.		G
	Unauthorised access to soffit.	Superstructure inaccessible to public.		G
Durability	Maintenance for future durability	No bearings required.	Maintenance of protective treatment system required.	F
Environment	Noise, local air quality, greenhouse gas emissions, land-take and transport		More visually intrusive. Greater landtake.	F

OPTION 11 – C30M SINGLE SPAN PRE-CAST PRE-STRESSED CONCRETE BEAM SUPERSTRUCTURE				
	CRITERIA	**BENEFIT**	**DISBENEFIT**	**GFP**
Aesthetics and Landscape Effects	Family of structures	Family of structures achievable.		G
	Open aspect/aesthetics		Semi-open aspect compared with 3-span alternative. Wing walls and abutment elevations visually more dominant than 3-span alternative.	F
Highway Alignment and Earthworks Balance	Impacts beyond the bridge location		Greater construction depths compared steel alternatives, greater earthworks to approaches, tie ins achieved later along side roads. Facetted soffit for crest curve structure. Gives awkward aesthetic appearance on crest curves.	F
Overall Construction Methodology and Approach and Safe by Design	Maintenance of haul route	Keeps haul route unobstructed – aligns with overall scheme philosophy.		G
	Transportable		Longer transport lengths than steel alternatives – psc beams cannot be broken into smaller lengths.	P
	Erectable/Buildability & Programme	Simple to construct, familiar construction.	Heavier lift weights, larger craneage. Possible temporary beam instability with “Paraslim” attached. Relatively large height integral abutments typically require upper bound limit to ϕ’ for backfill material to limit earth pressure effects, can lead to difficult yin sourcing appropriate backfill from site won material.	F
	Safe to construct	“Paraslim” and GRP formwork provides closed soffit safe working at height for constructing composite deck slab.		G
	Unauthorised access to soffit.	Superstructure inaccessible to public.		G
Durability	Maintenance for future durability	Fully integral – no bearings, no painting.		G
Environment	Noise, local air quality, greenhouse gas emissions, land-take and transport		More visually intrusive. Greater landtake.	F

	SUMMARY MATRIX	Option 1 3-span Steel Concrete Composite – Multi Beam Deck	Option 3 3-span PSC Beam Deck	Option 4 3-span In Situ Reinforced Concrete Deck	Option 5 Single 20m span Steel Concrete Composite – Multi Beam Deck	Option 7 Single 20m span PSC Beam Deck RE abutments	Option 7 Single 20m span PSC Beam Deck RC abutments	Option 9 Single 30m span Steel Concrete Composite – Multi Beam Deck	Option 10 Single 30m span Steel Concrete Composite – Ladder Beam Deck	Option 11 Single 30m span PSC Beam Deck
Aesthetics and Landscape Effects	Family of structures	G	G	G	G	G	G	G	G	G
	Open aspect/aesthetics	G	F	G	F	F	F	F	F	F
Highway Alignment and Earthworks Balance	Impacts beyond the bridge location	G	F	F	F	F	F	F	F	F
Overall Construction Methodology and Approach and Safe by Design	Maintenance of haul route	G	G	P	G	G	G	G	G	G
	Transportable	G	F	G	G	F	F	G	G	P
	Erectable/Buildability & Programme	G	F	F	F	F	F	F	F	F
	Safe to construct	G	F	F	G	G	G	G	G	G
	Unauthorised access to soffit.	F	G	G	G	G	G	G	G	G
Durability	Maintenance for future durability	F	G	G	F	G	G	F	F	G
Environment	Noise, local air quality, greenhouse gas emissions, land-take and transport	G	F	F	F	F	F	F	F	F

6.5.31 Applicability and Recommendations for Actual Overbridge Locations

6.5.31.1 S103 Ty'n Llan Overbridge (WG Asset Number A487 571)

Structure S103 Ty'n Llan Overbridge (WG Asset Number A487 571) carries a minor side road over the proposed A487 main line. The proposed structure is to be constructed on the line of the existing side road.

A preliminary plan of the structure location is illustrated in Figure 44 below.

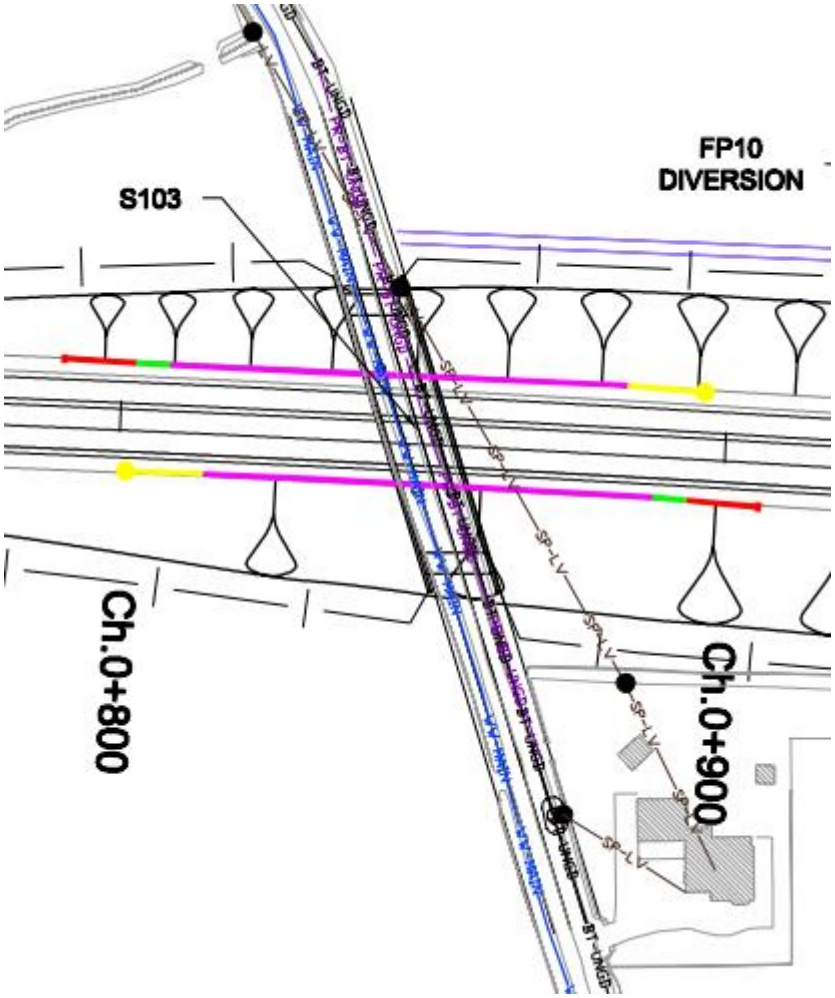


Figure 44. Draft Layout Plan abstract showing plan of Structure S103

The proposed side road section comprises a 1400mm verge to the low chainage (south) side, a 5500mm wide carriageway to match existing, and a 600mm verge to the high chainage (north) side.

At the location of the bridge, the A487 main line will be within a relatively deep cutting. From an aesthetic perspective along the main line, the preference is therefore for an open aspect to the structure, which would mean that Options 1 to 4 (3 span overbridges) and Options 9 to 11 (30m span overbridges) are the most appropriate structural forms.

The relative levels of the existing side road alignment and the proposed A487 main line are such that the bridge superstructure can be constructed on a straight vertical alignment at approximately existing ground level and provide a headroom of 5.4m (including an allowance for settlement and deflection). A straight grade vertical alignment can be readily accommodated by both steel concrete composite and pre-stressed concrete superstructures without adversely affecting the earthworks and tie-ins beyond the ends of the structure.

Based on the summary of comparative capital and whole life costs, for a structure in a cut situation, the ideal construction depth which will minimise the impact on the side road approaches and the earthworks balance along the A487 main line, and the desire to provide an open aspect structure in this cutting location, then:

- Option 1, a 3 span steel composite multi-beam deck, provides the lowest capital works cost solution.
- Option 3, a 3 span pre-cast pre-stressed concrete beam deck provides the lowest whole life cost solution.

On the basis of the provision of a minimum whole life cost structure, it is therefore recommended that Option 3, a 3 span pre-cast pre-stressed concrete beam deck, be adopted for Structure S103 Ty'n Llan Overbridge (WG Asset Number A487 571).

Statutory Undertakers' apparatus largely comprises 100mm and 150mm diameter ducts, which are proposed to be accommodated within the wider verge. It is anticipated that a 150mm diameter water main will be accommodated below deck level in a 225mm diameter sleeve, supported on stools above the pre-stressed concrete beam bottom flanges. The water main will need to be sleeved through internal pier and deck end diaphragms.

A ground investigation is currently being undertaken. The results of the investigation are being returned to the designers in order to assess the foundation requirements for each structure. Based upon this draft information, the proposed foundations for this structure are likely to comprise spread footings, as summarised in Appendix B. It should also be noted that as a result of consideration of ground investigation data available at the point of submission of this report, cut slopes of 1 in 2.5 are currently proposed, in lieu of the 1 in 2 assumed for option comparison and depicted in earlier figures.

The General Arrangement for the structure, based on the recommended Option 3, is contained in Appendix D.

6.5.31.2 S115 Bethel Road Overbridge (WG Asset Number A487 635)

Structure S115 Bethel Road Overbridge (WG Asset Number A487 635) carries the B4366 side road over the proposed A487 main line.

At the location of the bridge, the A487 main line will be within a very shallow cutting, with the B4366 Bethel Road side road supported on approach embankments either side of the bridge. The toe of the side road embankments will remain close to the existing B4366 alignment.

The proposed structure is to be constructed off line from the existing B4366 to allow the bridge and approach embankments to be constructed whilst the B4366 still carries

traffic. Following completion of the bridge and approach embankments, the B4366 will be diverted from its existing line onto the structure.

A preliminary plan of the structure location is illustrated in Figure 45 below.

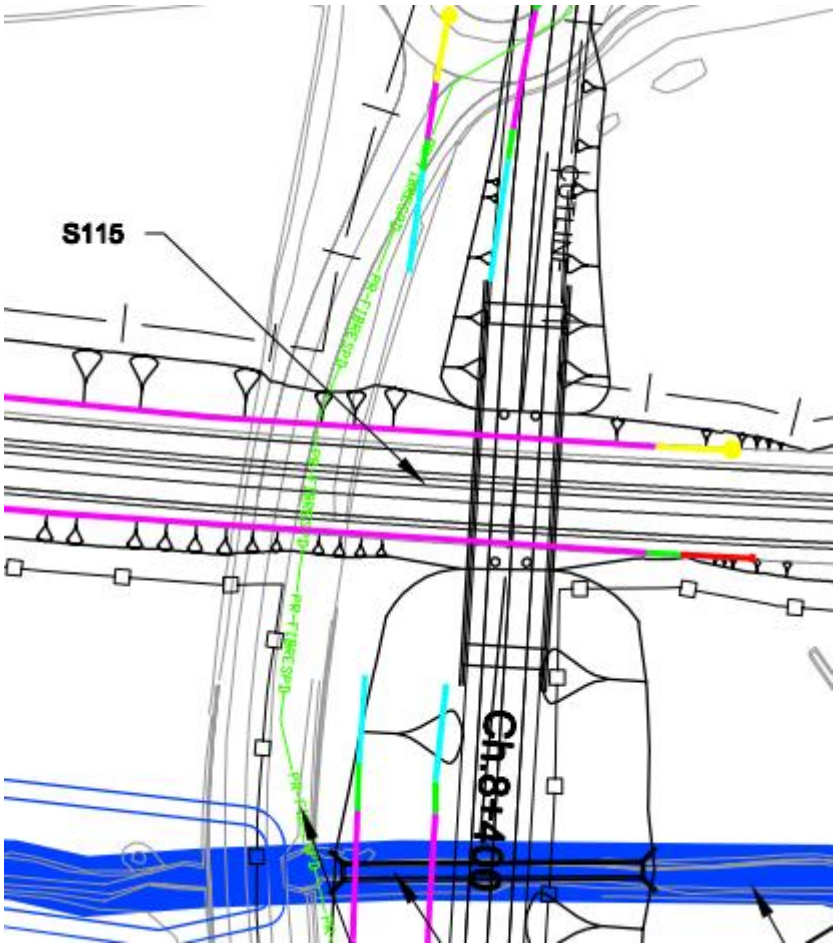


Figure 45. Draft Layout Plan abstract showing plan of Structure S115

The proposed side road section comprises a 600mm verge to the low chainage (south) side, a 7300mm wide carriageway, and a 1400mm verge to the high chainage (north) side. Departures from Standard are required in respect of the proposed 600mm verge width across Structure S115, both in terms of reduced set back to the VRS (*TD 27/05 Cross-Sections and Headrooms* clause 4.11.13) and the reduced visibility to the Bethel Road crossroads (*TD42/95 Geometric Design of Major/Minor Priority Junctions* Clauses 7.5 and 7.6) to the east of the structure.

From an aesthetic perspective along the main line, there is no particular preference for an open aspect structure, meaning that all options are considered possible solutions in this regard. For the c20m span options, it is proposed that the aesthetic impact of the wingwalls is reduced by aligning the wingwalls at approximately 45 degrees to the A487 main line. In this location, this will also provide the added construction advantage of moving the construction of the wingwalls and any associated lifting operations for the wingwall concrete fascia panels (in the case of reinforced soil) further away from the live B4366 carriageway.

The side road will be carried on a relatively small radius crest curve vertical alignment to rise up and pass over the main line, and thus the precast pre-stressed beam superstructure Option 3 can be discounted because of the faceting required in elevation to match the superstructure to the vertical road profile. The 30m span precast pre-stressed beam superstructure Option 11 also affords a disadvantage in this location as its greater construction depth and need for a straight vertical alignment over the superstructure length will require the side road alignment to be raised higher with consequential longer tie-ins and increased land take.

Based on the summary of capital and whole life costs, and consideration of the above at this location for a structure in a fill situation, then:

- Option 5, a c20m single span steel composite multi-beam deck, supported on reinforced soil abutments with reinforced soil wingwalls splayed at 45 degrees, marginally provides the lowest capital works cost solution.
- Option 7, a c20m single span pre-cast pre-stressed concrete beam deck supported on reinforced soil abutments with reinforced soil wingwalls splayed at 45 degrees provides the lowest whole life cost solution.

On the basis of the provision of a minimum whole life cost structure, it is therefore recommended that Option 7, a c20m single span pre-cast pre-stressed concrete beam deck supported on reinforced soil abutments with reinforced soil wingwalls splayed at 45 degrees, be adopted for Structure S115 Bethel Road Overbridge (WG Asset Number A487 635).

Statutory Undertakers' apparatus largely comprises 100mm and 150mm diameter ducts, which are proposed to be accommodated within the wider verge. It is anticipated that a 150mm diameter water main will be accommodated below deck level in a 225mm diameter sleeve, supported on stools above the pre-stressed concrete beam bottom flanges. The water main will need to be sleeved through the deck end diaphragms.

A ground investigation is currently being undertaken. The results of the investigation are being returned to the designers in order to assess the foundation requirements for each structure. Based upon this draft information, and very much subject to change depending upon receipt of further information and further consideration of potential settlements, the proposed foundations to the bridge structure are likely to comprise:

- Either piled supports to the reinforced concrete deck end bankseats, linked via reinforced concrete columns sleeved through the reinforced soil abutments.
- Or reinforced concrete deck end bankseats founded on spread footings above reinforced soil abutments, with ground improvement below the reinforced soil substructures.

Refer to Appendix B for further information regarding proposed foundations, together with limitations and appropriate caveats.

The General Arrangement for the structure, based on the recommended Option 7, is contained in Appendix D.

6.5.31.3 S109 Pont Ceriw NMU Overbridge (WG Asset Number A487 601)

For the substantial part of Key Stage 3 to date, Structure S109 Pont Ceriw NMU (WG Asset Number A487 601) was to be an overbridge accommodating a side road, for

which the structural form recommended would have been similar to that for Structure S115 Bethel Road Overbridge (WG Asset Number A487 635) based on Option 7, i.e. a c20m single span pre-cast pre-stressed concrete beam deck supported on reinforced soil abutments with reinforced soil wingwalls splayed at 45 degrees.

However, during the latter stages of Key Stage 3, current traffic flows and ongoing consultation with Gwynedd County Council have both informed an alternative, whereby the existing side road at this location is closed to through traffic, and the bridge over the A487 main line is to provide NMU access only.

At the location of the bridge, the A487 main line will be on a small embankment on side long ground, with the diverted NMU route supported on approach embankments either side of the bridge, in order to provide a minimum 5.7m headroom to the superstructure soffit. The proposed width of the NMU track across the bridge itself is 3.0m, to accord with *BD29/04 Design Criteria for Footbridges* Clause 12.4 in order to accommodate a segregated cycle path and pedestrian path.

Indications based on limited ground investigation information are that the structure will need to be supported on piled foundations.

A preliminary plan of the structure location is illustrated in Figure 46 below.

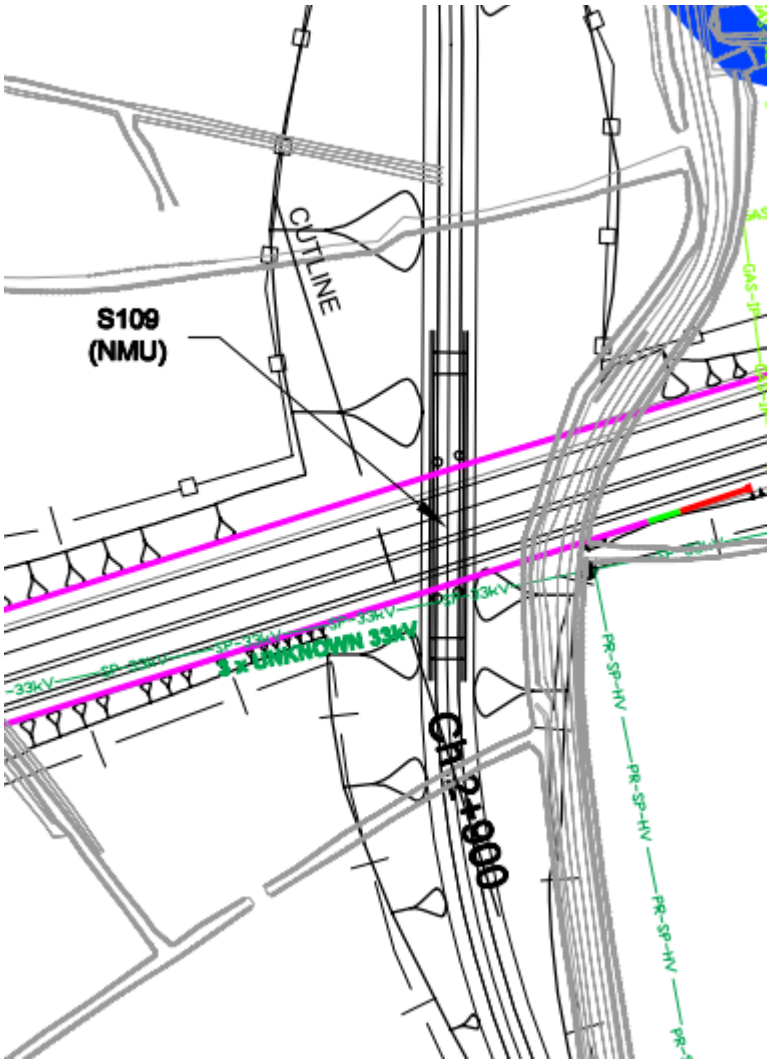


Figure 46. Draft Layout Plan abstract showing plan of Structure S109

The following options have been considered as alternatives for an NMU overbridge:

OPTION 1 - Single c20m span pre-cast pre-stressed concrete beam deck on reinforced soil or integral full height abutments.

This option would ostensibly comprise a narrower version of Option 7 described in detail for the road overbridges above.

This structural form would therefore be in-keeping with the proposals for Structures S115, both in terms of appearance, and in terms of providing a concrete structure with no bearings and hence a relatively low long term maintenance liability.

Option 1 is illustrated in Figures 47 to 49 below.

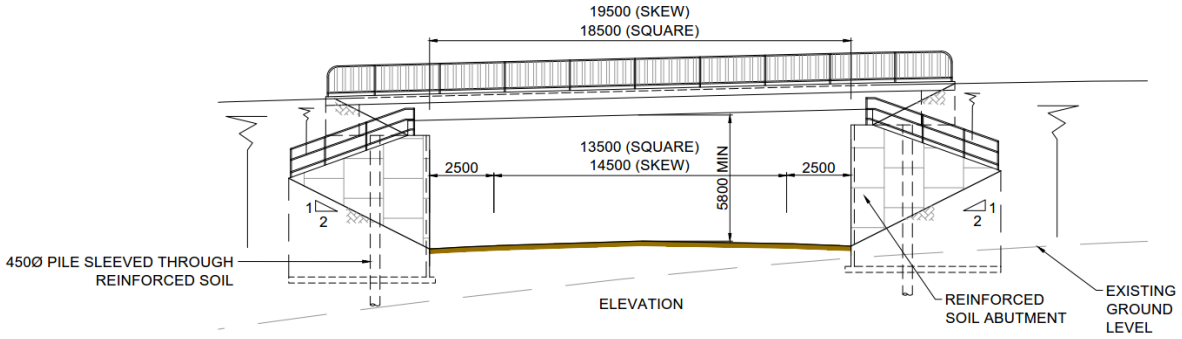


Figure 47 – Option 1 Elevation

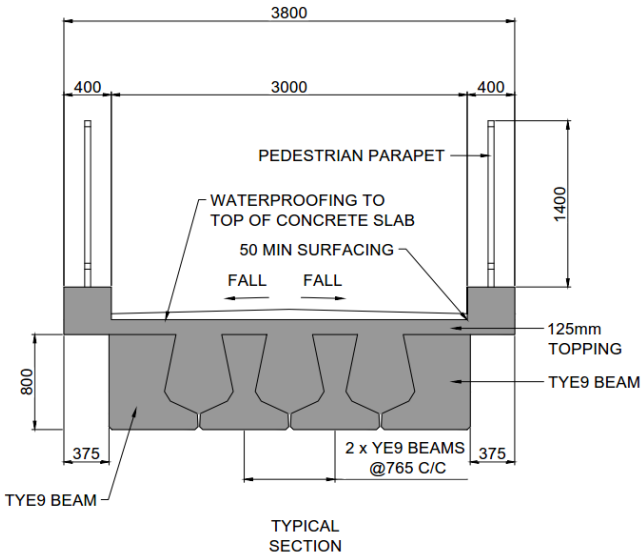


Figure 48 – Option 1 Deck Section

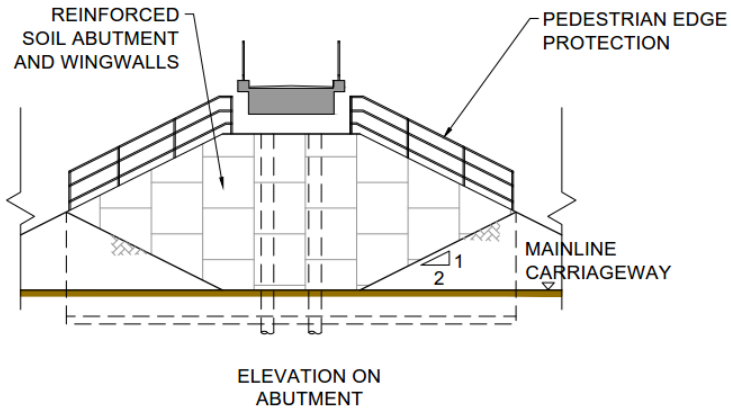


Figure 49 – Option 1 Abutment Elevation

The comparative capital and whole life cost of this option is £229,000.

OPTION 2 - Three span pre-cast reinforced concrete beam deck made integral with intermediate piers and bankseat abutments.

This option would comprise a pre-cast reinforced concrete beam deck, made integral with reinforced concrete piers and reinforced concrete bankseat abutments via in-situ stitches. This option would be similar to Option 3 as described in detail above for the road overbridges, but formed in reinforced concrete as opposed to pre-stressed concrete.

The advantage of reinforced concrete is that the superstructure can be cast at ground level to a vertical curve profile to reflect the vertical alignment of the NMU track over the bridge, thereby eliminating the awkward facetted appearance that a pre-stressed concrete beam solution would present, and eliminating the hazards usually associated with constructing in-situ superstructures at height.

Following casting, each span of the superstructure would be lifted into place directly onto the substructures using an appropriate mobile crane. As an alternative, the spans could be lifted onto temporary trestles either side of the pier supports. Fixing of continuity reinforcement between the deck and substructures would then precede pouring of the integral stitches.

This structural form would take the longest to construct of the options being considered.

This structural form would be in-keeping with the proposals for Structures S103, both in terms of appearance, and in terms of providing a concrete structure with no bearings and hence a relatively low long term maintenance liability.

Option 2 is illustrated in Figures 50 to 52 below.

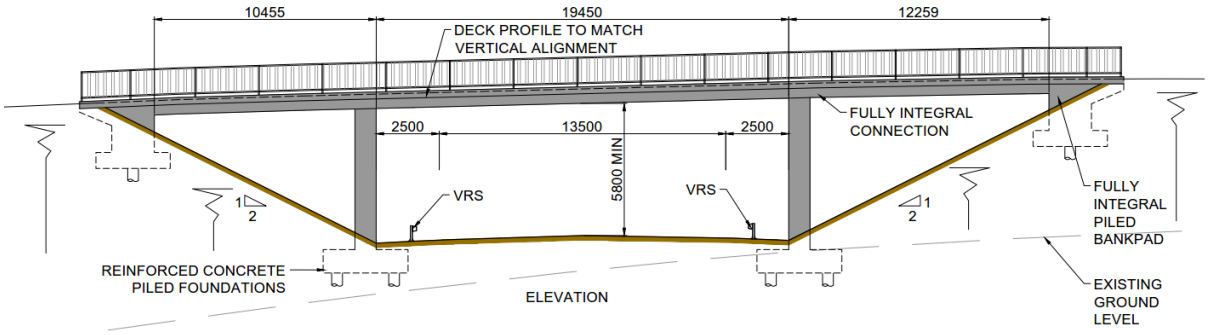


Figure 50 – Option 2 Elevation

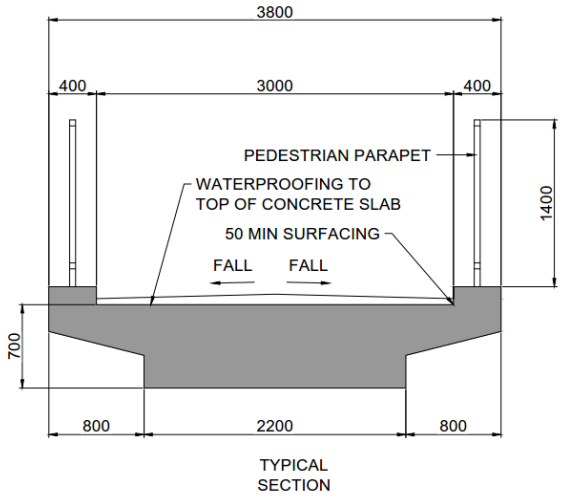


Figure 51 – Option 2 Deck Section

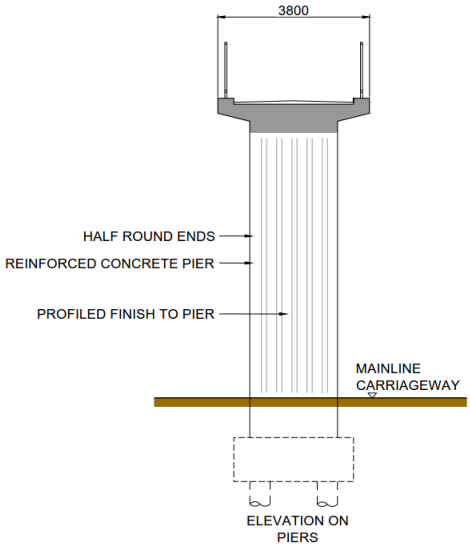


Figure 52 – Option 2 Pier Elevation

The comparative capital and whole life cost of this option is £239,000.

OPTION 3 - Single c35m span warren or pratt truss solution on reinforced concrete bank seats.

This option would comprise a single span half-through painted steel warren or pratt truss, simply supported on bearings above in-situ reinforced concrete bankseats.

Option 3 is illustrated in Figures 53 to 55 below.



Figure 53 – Option 3 Typical Warren Truss Footbridge, courtesy Nusteel Structures Limited

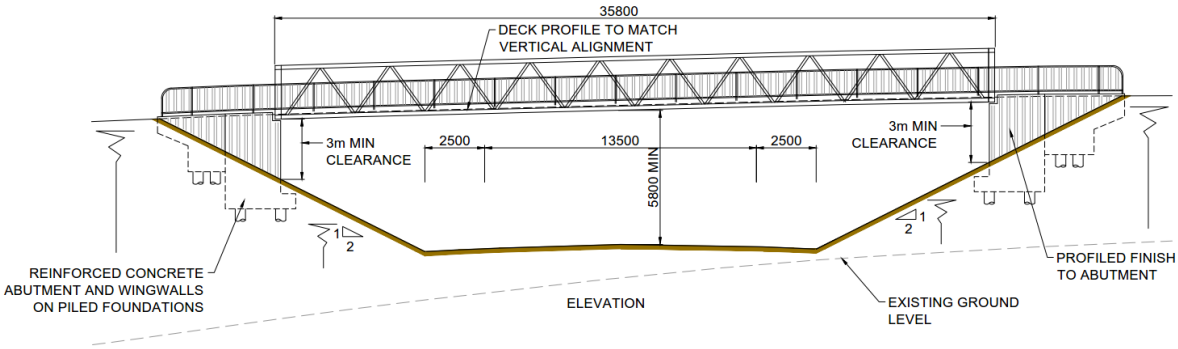


Figure 54 – Indicative Elevation

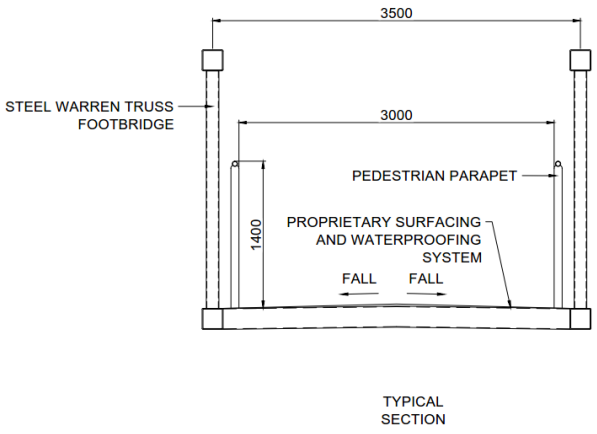


Figure 55 – Deck Section

Such structures are very lightweight compared with concrete alternatives. Surfacing would comprise a combined proprietary epoxy waterproofing and surfacing system, applied by the fabricator. Such lightweight bridges have the potential to provide significant savings in terms of foundation sizes, both as a result of their low weight, and as a result of the simply supported bearing arrangement which is tolerant of differential settlement between truss ends.

Option 3 could be brought to site, likely in two pieces, spliced at ground level, and lifted into place as a complete finished item in a single lift with a relatively modest crane, offering significant programme advantages over other forms of construction, and eliminating much work at height during construction compared with other options.

Unlike Options 1 and 2, Option 3 carries a greater maintenance liability. A complete grit-blast and repaint of the structural steelwork will typically be required at approximately 25 year intervals. This activity will require traffic management on the A487 and the provision of enclosures around the superstructure steelwork for the grit-blast and repainting activities. In addition, a mid-term maintenance intervention will typically be required to address minor breakdown of the protective treatment system and ensure that the 25 year major maintenance cycle is achieved. For the full re-paint scheme, it may be possible to temporarily close the bridge, lift it off-line, repaint it in its off-line location, and then lift it back into position.

The solution also proposes bearings above the bankseats, which would require maintenance painting under the same painting regime as the structural steelwork. It is anticipated that the bearings would be bespoke fabricated elements possessing the same 120 year design life as the main superstructure.

Despite the rural location, there is a perception that unauthorised access could be gained to the superstructure near bankseat abutments. To this end the substructures have been brought forward from their normal position in order to provide 3m headroom at their front faces.

Other than the increased maintenance liability, one of the key disadvantages of Option 3 is the aesthetic impact. The A487 Scheme passes through a rural landscape characterised by extensive views inland to Snowdonia and to the Menai Straits and to Anglesey, and the structural forms proposed to date are in-keeping with this rural context.

The use of a half-through bottom-loaded structure offers an advantage over Options 1 and 2 in terms of a very low construction depth, which would allow the approach embankments to be lowered by approximately 500mm to 700mm, potentially offering a reduced footprint from the earthworks, earlier tie-ins at each end of the approach embankments, and a lower visual impact associated with a lower projection of the embankments above the surrounding land. However, this advantage is more than offset by the truss superstructure depth of approximately 2.5m projecting above an approximately 9.5m high embankment relative to the surrounding land. Such a structure is not in-keeping with others proposed along the scheme, nor others along the A487 in the locality.

A further disadvantage compared with Options 1 and 2 arises out of any requirement for the bridge to accommodate equestrian users. Whilst the bridge width can be increased to 3.5m and taller 1.8m high parapets can be readily incorporated, warning notices or noise attenuation measures (for example special surfacing) would be required to avoid the sound made while crossing the bridge alarming the horses.

The comparative capital cost of Option 3 for Structure S109 is £264,000.

The comparative whole life cost of Option 3 for Structure S109 is £321,000.

Other Options Considered

Several other options have been considered and discounted.

As already stated above, a 3 span precast pre-stressed concrete beam solution has been discounted because of the undesirable facetted soffit required to fit the superstructure to the curved vertical NMU route alignment.

Steel composite top loaded (i.e. beam and concrete slab) structures have been discounted because of their greater whole life cost compared with the concrete alternatives, and the fact that a solution of this form would not fit with the family of concrete underbridge and overbridge structures which has largely arisen for the scheme.

Steel half-through plate girder bottom loaded solutions have been discounted in favour of lighter (both physically and in appearance) truss alternatives on the basis that the truss options provide a less utilitarian appearance in this rural location.

Land-mark type structures have not been considered as they are considered to be aesthetically inappropriate in the context of the rural landscape at this location, and would typically carry a cost premium.

Recommendation for Structure S109 Pont Ceriw NMU Overbridge (WG Asset Number A487 601)

On the basis of consideration of comparative capital works costs, comparative whole life costs, the appearance of the bridge form in the rural setting at this particular location, and along the A487 scheme as a whole, it is recommended that a single c20m span precast prestressed concrete beam deck on reinforced soil abutments is adopted at this location.

A ground investigation is currently being undertaken. The results of the investigation are being returned to the designers in order to assess the foundation requirements for each structure. Based upon this draft information, and very much subject to change depending upon receipt of further information and further consideration of potential settlements, the proposed foundations to the bridge structure are likely to comprise:

- Either piled supports to the reinforced concrete deck end bankseats, linked via reinforced concrete columns sleeved through the reinforced soil abutments.
- Or reinforced concrete deck end bankseats founded on spread footings above reinforced soil abutments, with ground improvement below the reinforced soil substructures.

Refer to Appendix B for further information regarding proposed foundations, together with limitations and appropriate caveats.

The General Arrangement for the structure, based on the recommended Option 1, is contained in Appendix D.

6.6 S108 Welsh Highland Railway (Pont Cefnwerthyd Bridge - WG Asset Number A487 591)

6.6.1 Introduction

The proposed A487 mainline passes over the Welsh Highland Railway (WHR) near the existing occupation level crossing from Cefnwerthyd Farm to Llanfaglan.

The WHR is a restored, narrow (597mm) gauge, heritage railway. For 2015, the railway operates a peak summer (May to August) service of six trains per day (three in each direction). In January 2015 and February 2015, there was only a single day of service timetabled. The railway is single track with a number of passing places along the route. A system of tokens is used to control train access to the single line sections, and operation is by train driver line of sight. The trains operate at low speed, with speeds of up to 25mph (although the current maximum speed is 20mph).

Smoke plates are to be provided above the railway track to protect superstructure elements from the effects of steam blasting from the locomotives on the WHR for all proposed deck forms.

A structure is required to not only pass over the single track WHR, but also to accommodate the occupation works needed to maintain access between parcels of land which will lie either side of the A487 mainline.

In addition, the structure also needs to accommodate a Public Footpath/Cycleway Recreation route which runs alongside the railway.

At Key Stage 2, and during the early part of Key Stage 3, consideration was initially given to the provision of a bridge to span over:

- The WHR railway line;
- A separate footpath/cycleway to the southern (low chainage) side of the railway;
- Two farm accommodation access tracks, one to each side of the railway, connected by a single level crossing of the railway.

The above constraints necessitate a clear span in the order of 17m.

However, various discussions with stakeholders during Key Stage 3 have established that the constraints at this location can be met through the provision of a bridge to span over:

- The WHR railway line;
- A separate footpath/cycleway to the southern (low chainage) side of the railway;
- A single farm accommodation access track located to the northern (high chainage) side of the railway.

The provision of a single farm accommodation access track below the bridge requires the provision of two level crossings across the WHR, which is an increase above the single level crossing currently provided in this location. Both WHR and Office of Rail and Road (ORR) have been consulted regarding the level crossing proposal, and indications are that the provision of two level crossings in lieu of a single level crossing would be acceptable.

The above constraints necessitate a clear span in the order of 12m.

6.6.2 Headroom and Lateral Clearances Constraints

Structures passing over the heritage WHR tracks are to provide a minimum of 3.65m headroom, and 2.0m lateral clearance from the centre-line of the track to substructure faces and fence lines, based on the Ffestiniog Railway Company Civil Engineering Department Porthmadog 'Load & Structure Gauge (Welsh Highland Section)" gauge dimensions set out on Drawing PW30A supplied by the WHR, and contained in Appendix A. Topographical survey information shows that existing fence-lines between the WHR and the cycle track in the vicinity of the proposed bridge crossing are already set out at approximately 2000mm offset to the track centre-line.

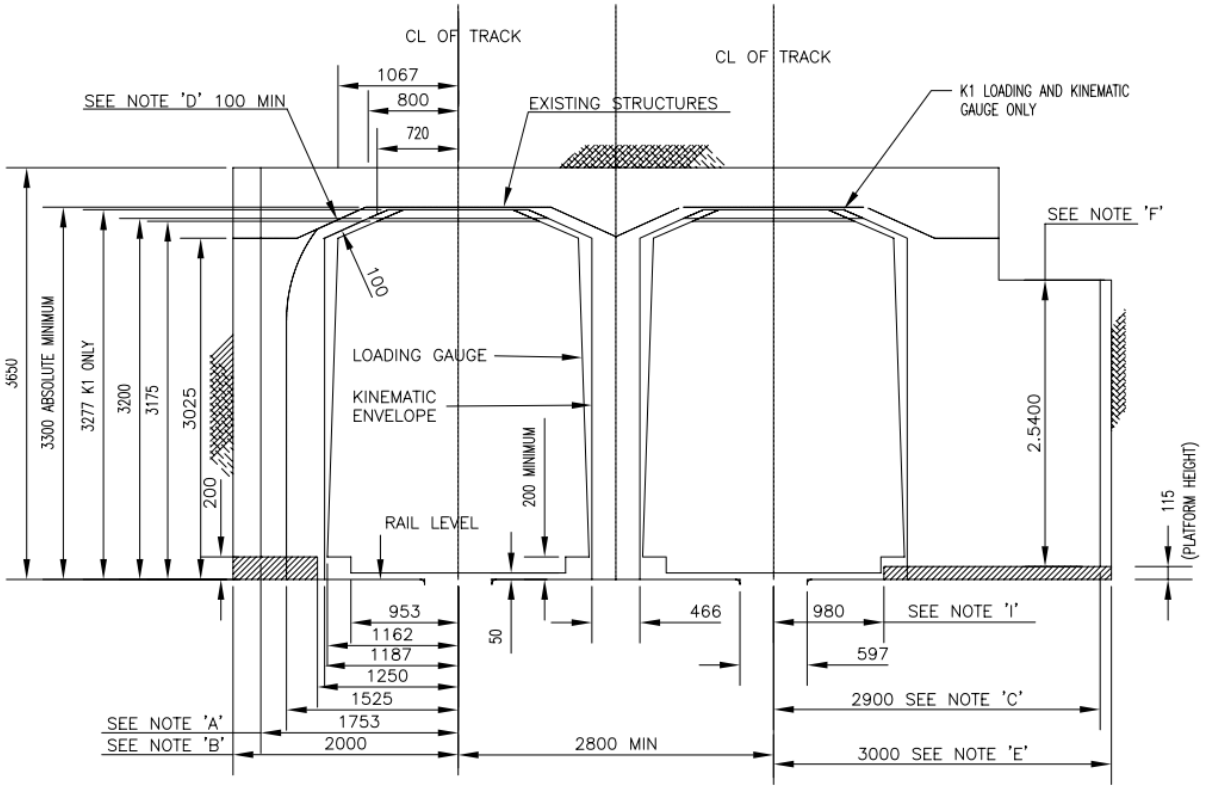


Figure 56. Abstract from 'Load & Structure Gauge (Welsh Highland Section)" gauge dimensions set out on Drawing PW30A

Whilst the desirable minimum headroom clearance above the railway is 3.65m, the headroom clearance above the occupation tracks to accommodate farm machinery is greater at 4.5m, and it is thus this latter headroom requirement which constrains the A487 mainline highway vertical alignment and the associated bridge design.

The bridge over the WHR is a high spot along the A487 main line vertical alignment, and so the combination of the required headrooms above the obstacles below and the construction depth of the bridge deck superstructure very much inform the earthworks requirements along this section of the route.

Where the farm accommodation access track passes below the bridge adjacent to substructures, a nominal 500mm verge offset has been provided to the rear of kerb

faces to reduce the likelihood of the risk of collision from the low speed agricultural machinery passing below the structure. This accords with the recommended section contained within the *Report of the Study Group on Dimensions of Agricultural Bridges and Underpasses* published by MAFF and the Department for Transport), referred to in Clause 5.11.3 of *TD27/05 Cross-Sections and Headrooms.* The land is not intensely farmed and is generally used for grazing sheep, and it is anticipated that the access track and level crossings would typically be used to accommodate a tractor and trailer rather than heavy machinery.

The proposed 2m width of the Public Footpath/Cycleway Recreation route below the bridge matches the current width provision in the vicinity. 500mm wide verges are proposed to each side of the footpath/cycleway, i.e. to the abutment face and fence on either side.

6.6.3 Span arrangements, choice of construction materials and safe by design

It is proposed that access for construction of this bridge will largely be along the A487 mainline haul route. During construction, it is proposed that an at-grade level crossing of the WHR is provided for use by construction plant and machinery, and that this be signal/gate controlled. There is a clear desire that construction should have a minimal impact on the operation of the WHR, and in consultation, WHR has expressed a preference for works to largely be completed during their approximate 2 month "closed" season, between the start of January and the end of February, each year, where practicable.

For the bridge itself, the structures design options considered seek to minimise the impact on the operational heritage railway through the use of pre-cast or pre-fabricated superstructure elements which can be quickly lifted into place above the railway line to create a closed soffit for ensuing construction operations.

Substructures are to be located at sufficient distance from the track as to allow them to be largely constructed whilst the railway is still in operation. Formal possessions of the track will be required in order to undertake certain construction activities, but mitigation for any disruption will be through the timing of such operations, for example in the "closed" season, during overnight possessions, or between trains, depending on the particular construction activity being undertaken.

Since, at this bridge site, the A487 mainline is to be constructed on embankment to cross the WHR and occupation tracks with adequate headroom, the site geometry and constraints lend themselves to consideration of either a 3 span or single span underbridge solution, with either steel concrete composite or pre-stressed concrete beam superstructures.

Access for maintenance for all structural forms will be from the A487 highway alignment above, or from the ground below.

A summary of the options applicable at this location are summarised in the table below:

	Superstructure Materials			
Span arrangement	**Steel concrete composite multi-beam deck**	**Steel concrete composite ladder deck**	**Pre-cast pre-stressed concrete beam deck**	**In-situ reinforced concrete deck**
3 span superstructure	Option 1	Option 2	Option 3	Option 4
Single span superstructure Reinforced soil abutments Reinforced concrete abutments	Option 5	Option 6	Option 7	Option 8

Description and consideration of the various options set out in the table above has already been presented in the Overbridge section of this report using the same option numbers, and the salient points and summaries are also applicable to the bridge structure over the WHR.

From the work undertaken for Overbridges, it is concluded that the optimum solution at this location comprises Option 7. Option 7 comprises a pre-cast, pre-stressed concrete beam deck, either supported on reinforced soil abutments or, alternatively, supported on integral reinforced concrete abutments. Both variations are as described in the Overbridge section above and therefore the detail will not be repeated here. However, the applicability of Option 7 to the actual bridge site is set out below.

6.6.4 Applicability of Option 7 Alternatives to WHR Location

For the 12m clear span solution incorporating one farm accommodation access track (as opposed to a 17m solution spanning two farm accommodation access tracks), a single span solution is more appropriate than a 3 span solution, and thus Option 7 provides an appropriate solution.

A single span underbridge at this location is also consistent with other underbridges along the scheme, so maintaining a family principle in terms of underbridge form.

A pre-cast, pre-stressed concrete superstructure on either form of substructures offers a low maintenance solution. The provision of a durable structure and the associated minimisation of potentially disruptive maintenance are beneficial not only to WG, but also to the various stakeholders below the structure – i.e. the landowner/farmer, the WHR and the public using the footway/cycleway Recreation route.

A preliminary plan of the structure location is illustrated in Figure 57 below.

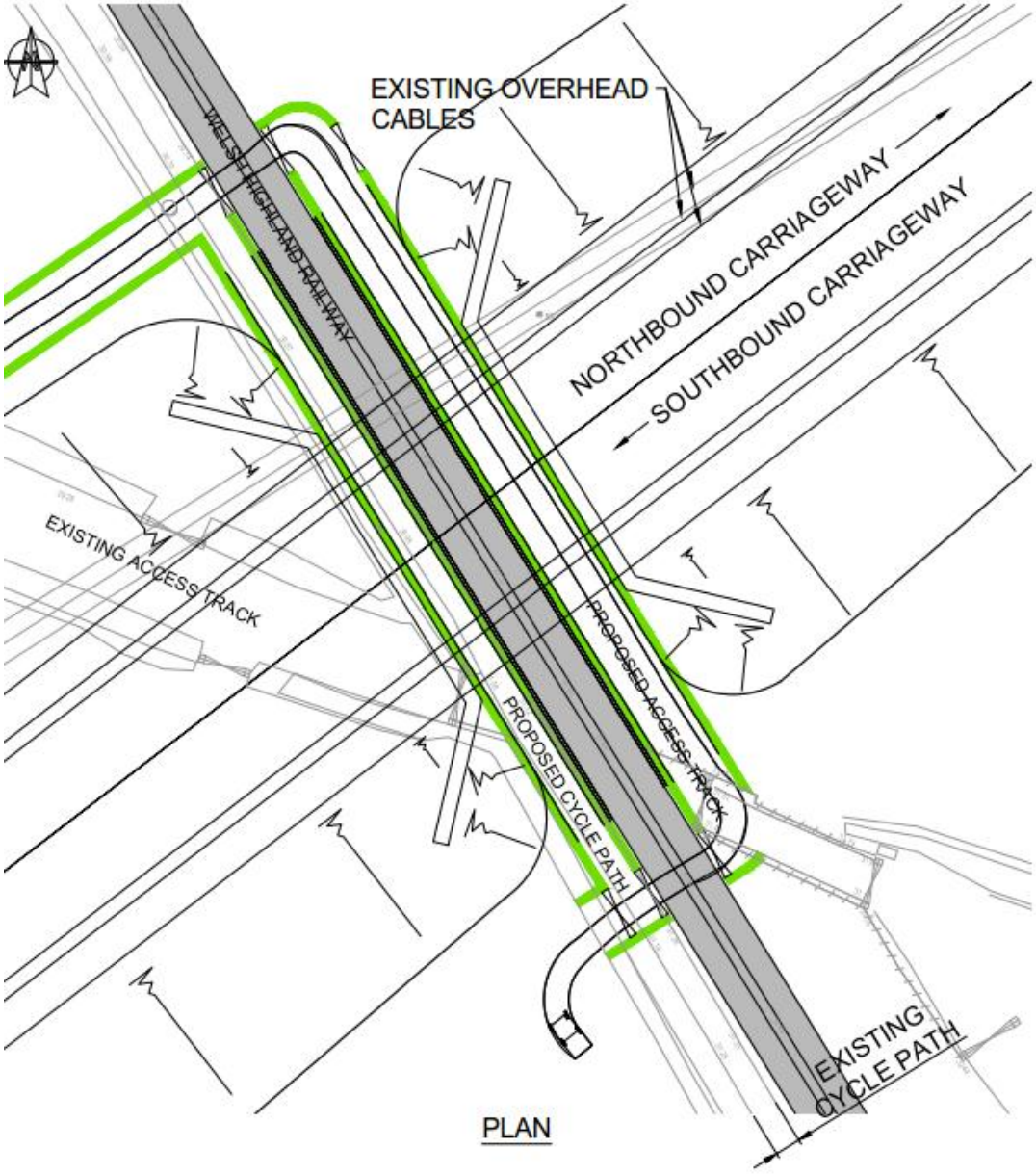


Figure 57. Plan of structure location

6.6.4.1 OPTION 7 – Single Span Pre-cast Pre-stressed Concrete Beam Superstructure on Reinforced Soil Abutments

Option 7 with reinforced soil abutments is illustrated in Figures 58 to 60 below.

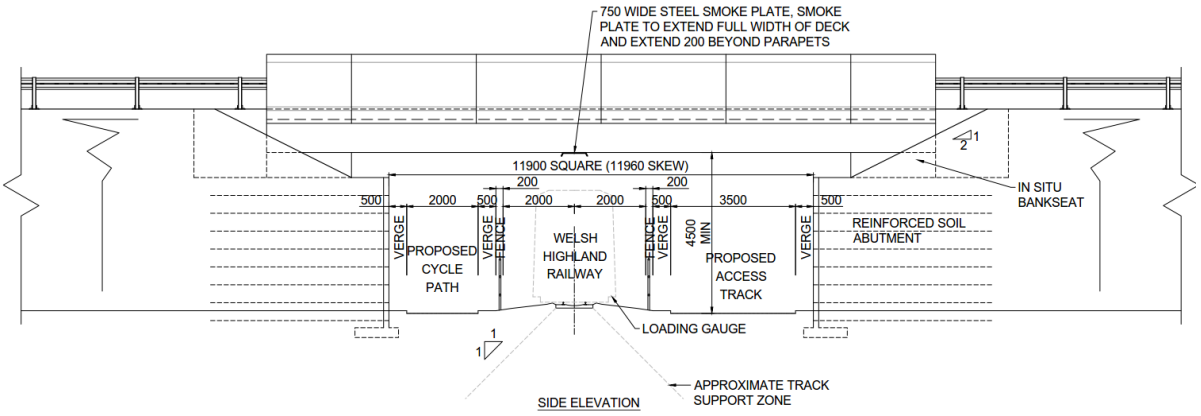


Figure 58. Elevation depicting reinforced soil substructures

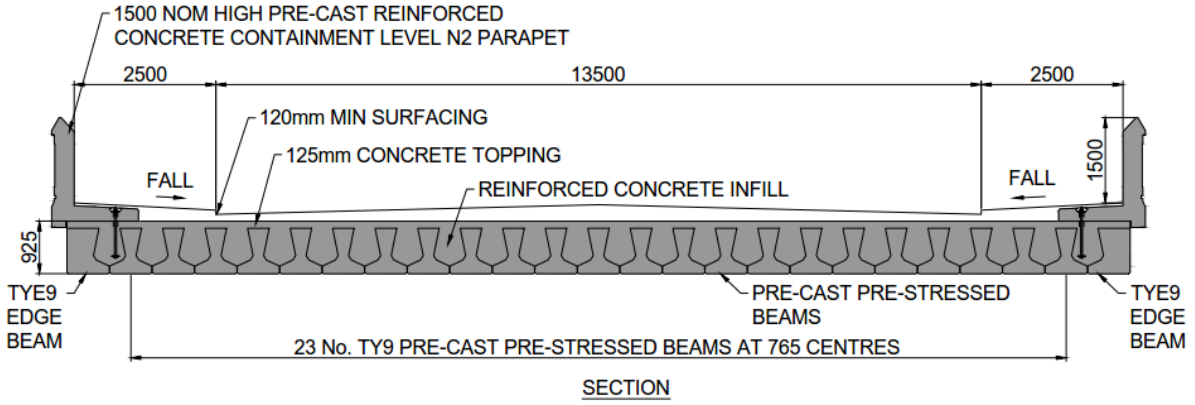


Figure 59. Superstructure cross section

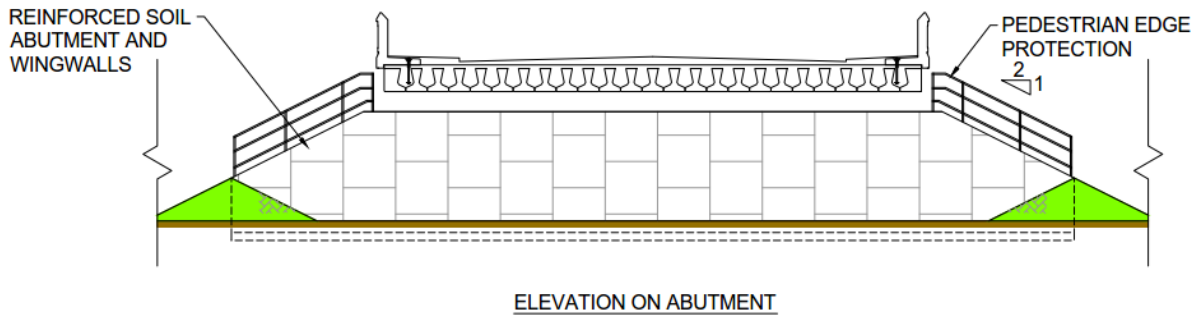


Figure 60. Elevation on abutment and wingwalls depicting reinforced soil substructures

For this option, the reinforced soil abutments and wingwalls could be constructed at the same time as the placement of the embankment fill supporting the A487 main line on the approaches to the structure. Early construction with the embankment has the

potential to allow any underlying settlement to occur prior to construction of the first stage bankseat pour. Constructing the bridge substructures and embankment approaches simultaneously affords construction programme advantages compared with the reinforced concrete integral substructure alternative, and requires less work involving craneage in proximity to the WHR.

The foundations for the reinforced soil substructures are typically contained within the footprint of the embankment, with only a small strip footing to support the concrete facing typically projecting beyond the face of the abutments. The remote location of the foundations to the reinforced soil substructures allows them to be constructed at a significant distance from the WHR, placing them very much outside the track support zone, and thus minimising the potential disruption to the operation of the railway through construction activities. Settlement monitoring of both the tracks and the substructures would be undertaken through the construction process, to understand and advise of any mitigation for maintaining WHR track levels as a result of potential settlement, and to confirm that settlement has slowed to an acceptable rate prior to commencement of superstructure construction.

The relatively short span lends itself to a shallow construction depth using TY and TYE pre-cast, pre-stressed concrete beams which, when in-filled and topped with in-situ concrete, create a robust and durable solid slab deck superstructure. The advantage of such a deck form is that it creates a closed superstructure immediately upon landing the beams which, when sealed, allow superstructure construction activities to continue over the operational railway largely unhindered by the presence of the railway below.

In addition, although the bridge deck would be fully integral with the bankseat end support, the design is, in essence, a simply supported solution, and this could afford a relatively rapid design and independent check allowing this to be an early structure to be completed along the scheme.

6.6.4.2 OPTION 7 – Single Span Pre-cast Pre-stressed Concrete Beam Superstructure on Reinforced Concrete Abutments

Option 7 with reinforced concrete integral abutments is illustrated in Figures 61 to 63 below.

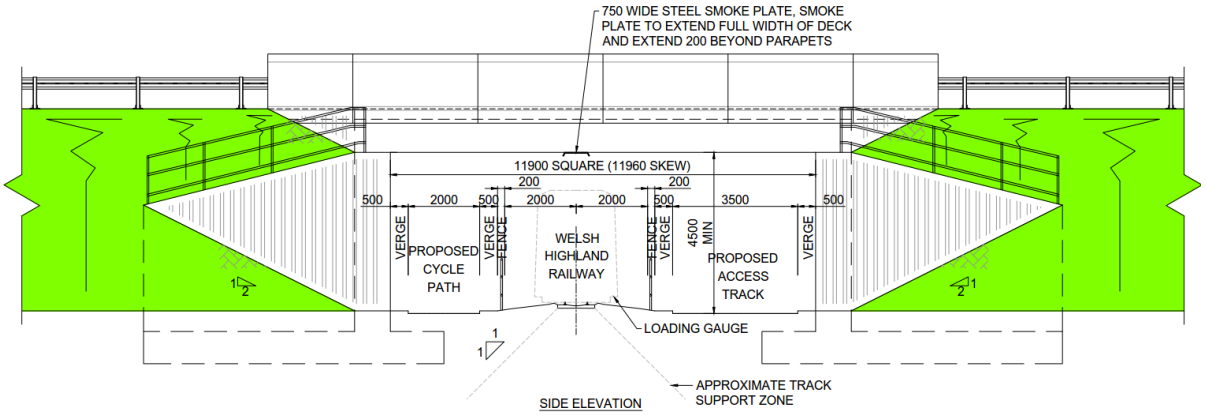


Figure 61. Elevation depicting reinforced concrete substructures

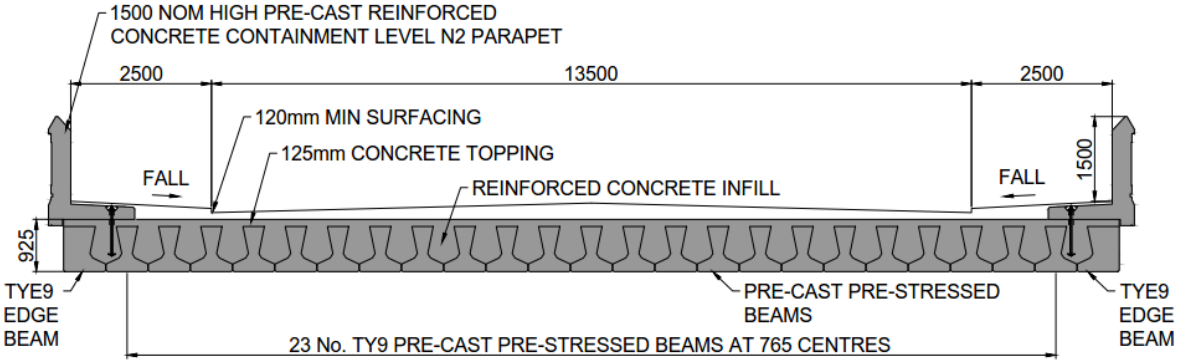


Figure 62. Superstructure cross section

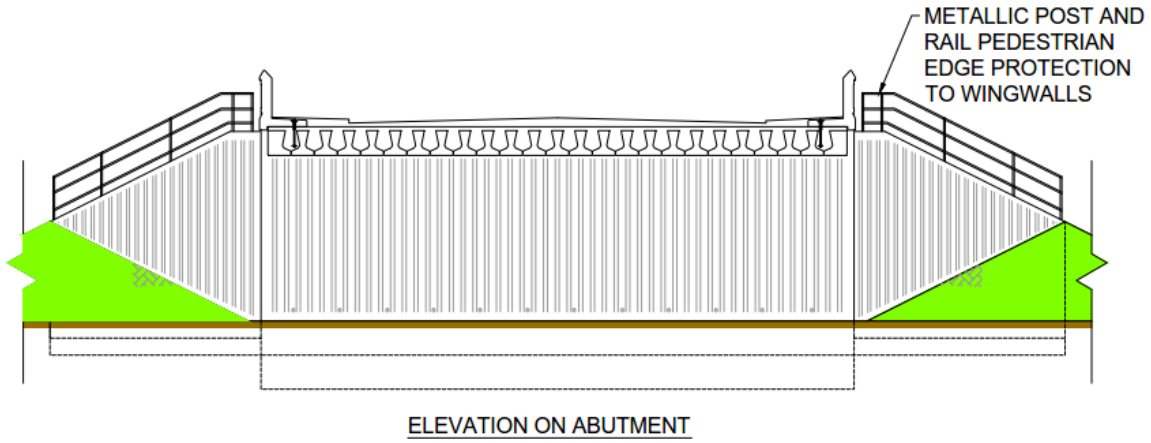


Figure 63. Elevation on abutment and wingwalls depicting reinforced concrete substructures

For this option, the reinforced concrete foundations would need to be constructed first. Following this, the abutment and wingwall stems would need to be fixed and poured to the level of the superstructure soffit, and once cured, the shutters struck. Landing of the pre-cast pre-stressed concrete beams would then be followed by fixing of more substantial deck reinforcement than the reinforced soil option in order to make the integral hogging moment connection between the deck and the abutments. Following the pouring and curing of the superstructure and integral connection, the portal structure would then be backfilled. Backfilling would need to be carried out virtually evenly to the rear of each abutment in order to mitigate deleterious sway effects within the portal frame structure.

The greater and more complicated number of construction stages, with associated curing, would mean that this option will likely take longer to construct than the reinforced soil option, and will require more work involving craneage (particularly for shutters and reinforcement fixing to the wall stems and bases) in proximity to the WHR.

The foundations for the reinforced concrete substructures would typically extend beyond the faces of the abutments and wingwalls, placing them in closer proximity to the WHR, but still outside the track support zone. Settlement monitoring of both the tracks and the substructures would again be undertaken through the construction

process, to understand and advise of any mitigation for maintaining WHR track levels as a result of potential settlement.

The relatively short span superstructure again lends itself to a shallow construction depth using TY and TYE pre-cast, pre-stressed concrete beams, as described above. A slightly shorter effective span and the beneficial effects of end fixity into the integral abutments will likely lead to a minor saving on the superstructure construction depth.

6.6.5 Parapets

The vehicular parapets proposed for the bridge superstructure, above the railway track and farm access track, comprises 1500mm high Normal Containment Level (N2) with solid infill, in lieu of the Very High Containment Level (H4a) vehicle parapet as set out in *TD19/06 Requirement for Road Restraint Systems* Clause 4.6.

The following are considered to be relevant and will be dealt with in greater detail within a proposed Departure from Standard:

- The requirement for Very High Containment Level vehicle parapets can lead to a very heavy design which can be difficult to construct and appear heavy, particularly any VRS on the approaches.
- *TD19/06* Clause 4.6 does not differentiate between different types of railway – a high speed, high volume of traffic express passenger railway is considered equal to a slow speed, low volume of traffic heritage railway - in the instance of the Welsh Highland Railway.
- The railway is a restored, narrow gauge heritage railway.
- The railway operates a peak summer service of 6 No. trains/day (3 No. in each direction) and in January and February, there is a single day of service only.
- The railway is single track with a number of passing places along the route.
- The maximum speed of trains on the railway is 25mph.
- *ORR Railway Safety Publication 5 Guidance on Minor Railways* Clause 134 states that "'High containment' parapets should be provided where the likelihood of impact with the parapet and consequential damage outweigh the hazards resulting from the containment and redirection of errant road vehicles within the traffic stream".
- An initial risk assessment undertaken using the guidance contained in *DfT Managing the Accidental Obstruction of the Railway by Road Vehicles* gives an overall score of 37 which means that risk is approximately 100 million times lower than a score of 90 – the score at which an intervention would normally be considered by Network Rail and local highway authorities on the mainline network.
- An initial Road Restraint Risk Assessment Process (RRRAP) assessment has been undertaken based on *TD19/06* which indicates that N2 Normal Containment level would be adequate if a VRS were being provided rather than a parapet.
- The verge widths across the bridge are large with the parapet itself set back from the edge of the carriageway, which acts as mitigation.

Both the ORR and the Welsh Highland Railway have been consulted regarding the proposed adoption of Normal Containment Level (N2) parapets, and indications are that this would be acceptable subject to an appropriate risk-based justification.

6.6.6 Capital and Whole Life Costs

From costing work completed for the generic overbridge solutions, the Option 7 pre-cast pre-stressed beam solution constructed on reinforced soil substructures afforded lower capital and whole life costs than the solution constructed on reinforced concrete substructures.

6.6.7 Recommendation for S108 Welsh Highland Railway (Pont Cefnwerthyd Bridge - WG Asset Number A487 591)

On the basis of:

- Minimum capital and whole life costs.
- Durable, low maintenance structure.
- Significant programme benefits arising from relatively rapid design, independent checking and construction, with the potential to minimise adverse effects on the WHR.

It is recommended that the solution at this location comprises a single span, pre-cast, pre-stressed concrete beam superstructure, made fully integral with reinforced concrete deck end bankseats, all supported on reinforced soil substructures. Normal Containment Level (N2) vehicle parapets are proposed subject to a Departure from Standard.

A ground investigation is currently being undertaken. The results of the investigation are being returned to the designers in order to assess the foundation requirements for each structure. Based upon this draft information, and very much subject to change depending upon receipt of further information and further consideration of potential settlements, the proposed foundations to the bridge structure are likely to comprise:

- Either piled supports to the reinforced concrete deck end bankseats, linked via reinforced concrete columns sleeved through the reinforced soil abutments.
- Or reinforced concrete deck end bankseats founded on spread footings above reinforced soil abutments, with ground improvement below the reinforced soil substructures.

The adoption of piled foundations is not anticipated to present any issues with regard to proximity to the WHR provided adequate control measures are implemented to prevent any risk of the piling rig overturning and blocking the railway.

Refer to Appendix B for further information regarding proposed foundations, together with limitations and appropriate caveats.

The General Arrangement for the structure, based on the recommended solution, is contained in Appendix D.

6.7 S106 Afon Gwyrfai Viaduct (WG Asset Number A487 581) – Conforming Design

6.7.1 Introduction

The A487 mainline is proposed to cross the Afon Gwyrfai and its associated flood plain to the west of Bontnewydd on viaduct.

The Afon Gwyrfai forms part of the Afon Gwyrfai a Llyn Cwellyn Special Area of Conservation (SAC) and is particularly noted for its excellent salmon population, for which it is considered to be one of the best supporting rivers in the United Kingdom. It is also noted for its otter population.

Key Stage 2 works

At Key Stage 2, the structure length, level and carriageway cross section were contained within mandatory budget assumptions.

Topographical survey information was based on Ordnance Survey data with a relatively low level of resolution. Coupled with the flat, low lying nature of the ground, this meant that the ground levels depicted could vary by 1-2 metres from the actual ground levels which would only be confirmed by detailed topographical survey during Key Stage 3.

Furthermore, no hydrological modelling of the catchment had been undertaken and hence the impact of the proposed viaduct on flood levels was not known at that stage. There had also been only limited discussion with statutory organisations such as Natural Resources Wales.

However, the mandatory budget assumptions at tender mean that these issues were not explored in detail.

Key Stage 3 works

With numerous highway design iterations for both the A487 main line and side roads, ground investigation works, topographical survey works, flood modelling, iterations for earthworks to achieve a cut fill balance, Public Information Exhibitions and other stakeholder liaison, all progressing in parallel during the early part of Key Stage 3, and with any recommendations informing the scheme structures content then coming near the end of the programmed period for production of the Design Options Reports, there have been many challenges in providing a number of options for this particular viaduct for an evolving design in a restricted programme.

The approach taken has therefore been to develop likely solutions appropriate to the numerous constraints for comparative purposes, and apply and refine the outcome of this work to meet the specific details and constraints at the structure location which have crystallised out of the design process following receipt of topographical survey information, ground investigation information, flood modelling outputs, stakeholder feedback, freezing of the highway alignment, etc.

Key constraints at this location which have informed the development of a number of options for comparison purposes include:

- Mandatory budget assumptions regarding viaduct length, carriageway cross section and level.

- The plan location and extents of the flood plain to the River Gwyrfai.
- Provision of 600mm freeboard above maximum flood level;
- Welsh Government TAA requirement for 3.0m soffit clearance to ground level to prevent unauthorised access to soffit elements where hand-holds can be gained.
- Provision of adequate lateral clearance to the SAC, where the SAC is bounded by the banks of the River Gwyrfai.
- Provision of a passage around the substructures to facilitate river maintenance access along the river banks.
- In addition to the above, following consultation with affected landowners, consideration has also been given to the provision of headroom clearance of 4.5m along part of the length of the viaduct to allow for farm access between fields to mitigate against the effects of severance.

As Key Stage 3 has progressed and the detailed information above has become available, alternative viaduct arrangements to those dictated by the mandatory budget assumptions have been considered as part of a value engineering exercise. These are reported separately below.

For the purposes of this report, the options considered to deliver a structure complying with the mandatory budget assumptions will hereinafter be referred to as the Conforming Design.

6.7.2 Span arrangements and choice of construction materials

Conforming Design

The mandated structure length is 280m overall (including wing walls) with 260m measured from abutment to abutment face, to extend virtually the full width of the floodplain. At the location of the viaduct, the Key Stage 3 highway alignment initially consisted of a large plan radius of approximately 7000 metres, and a straight vertical profile on a longitudinal gradient falling gradually to the south end of the structure.

At the bridge location, the Key Stage 3 A487 horizontal alignment initially crossed the existing river channel at a skew requiring a large square span of 32.5m to clear the water course.

The extent of the SAC is the river channel and hence options have been developed which avoid working in the channel. This will likely involve constructing sheet pile cofferdams in which to construct the foundation bases for those piers adjacent to the watercourse. It is proposed that the cofferdams will be retained post construction, albeit with the sheet piles cut down to below ground level which will provide scour protection to the piers and avoid further river training or bank protection works along the course of the river channel upstream and downstream of the structure.

The river channel is located at the northern edge of the flood plain and has been considered within the end span at the northern end of the viaduct.

As a result of the above, a structure having 8 equal square spans of 32.5metres has been considered. Skewing of spans has not been considered since the leaf piers, which, as will be seen, are preferred for the proposed structure form, will present a greater obstruction to the flood plain and predominant direction of flood water flow

than having square spans. Skewing the spans also creates added complexity in the design, detailing and construction of substructures and superstructures.

Options for the viaduct superstructure consider continuous spans, with fixed bearings longitudinally at the southern end.

The road vertical alignment is generally low lying to the existing ground level and consequently reinforced concrete leaf piers have been considered for the intermediate supports, rather than piers with columns and crossheads or discrete columns with crossheads integral with the deck. This arrangement simplifies not only construction of the piers themselves but also the construction of the superstructure.

At each end of the viaduct, abutments will be provided with inspection galleries to provide full touching distance access to bearings.

Construction Materials

Notwithstanding, the length of viaduct, the options for superstructure type are considered to be equivalent:

- Steel /concrete composite multi-girder deck;
- Steel/concrete composite ladder deck;
- Precast pre-stressed concrete beam deck;
- In situ reinforced concrete deck.

Each of the deck options identified above is briefly described below. Principal element sizes have been typically determined from a combination of preliminary sizing exercises, use of available look-up tables and/or manufacturers' data sheets, blended with experience of similar structural forms on other highway schemes.

For each of the options, consideration has been given to:

- Outline construction methodology.
- Review of the proposed structural form against the Context for Structures and Other Factors Affecting Choice identified in Sections 4 and 5, respectively, above.
- Comparative capital cost for construction.
- Comparative whole life cost with due regard to maintenance requirements during the working life of the structure.

6.7.3 OPTION 1 - Steel /concrete composite multi-girder deck

<u>Description</u>

This comprises:

- Multi span steel concrete composite superstructure with 5 parallel steel beams.
- Reinforced concrete leaf piers with rounded ends and reinforced concrete end abutments, incorporating inspection galleries, assumed to be founded on piled foundations for comparison purposes.

- Supported on bearings and continuous over intermediate piers. Simply supported at end abutments, fixed at the lower southern end.
- Deck joint details would be a fixed joint at the lower southern end with a movement joint at the higher northern end.

Option 1 is illustrated in Figures 64 and 65 below.

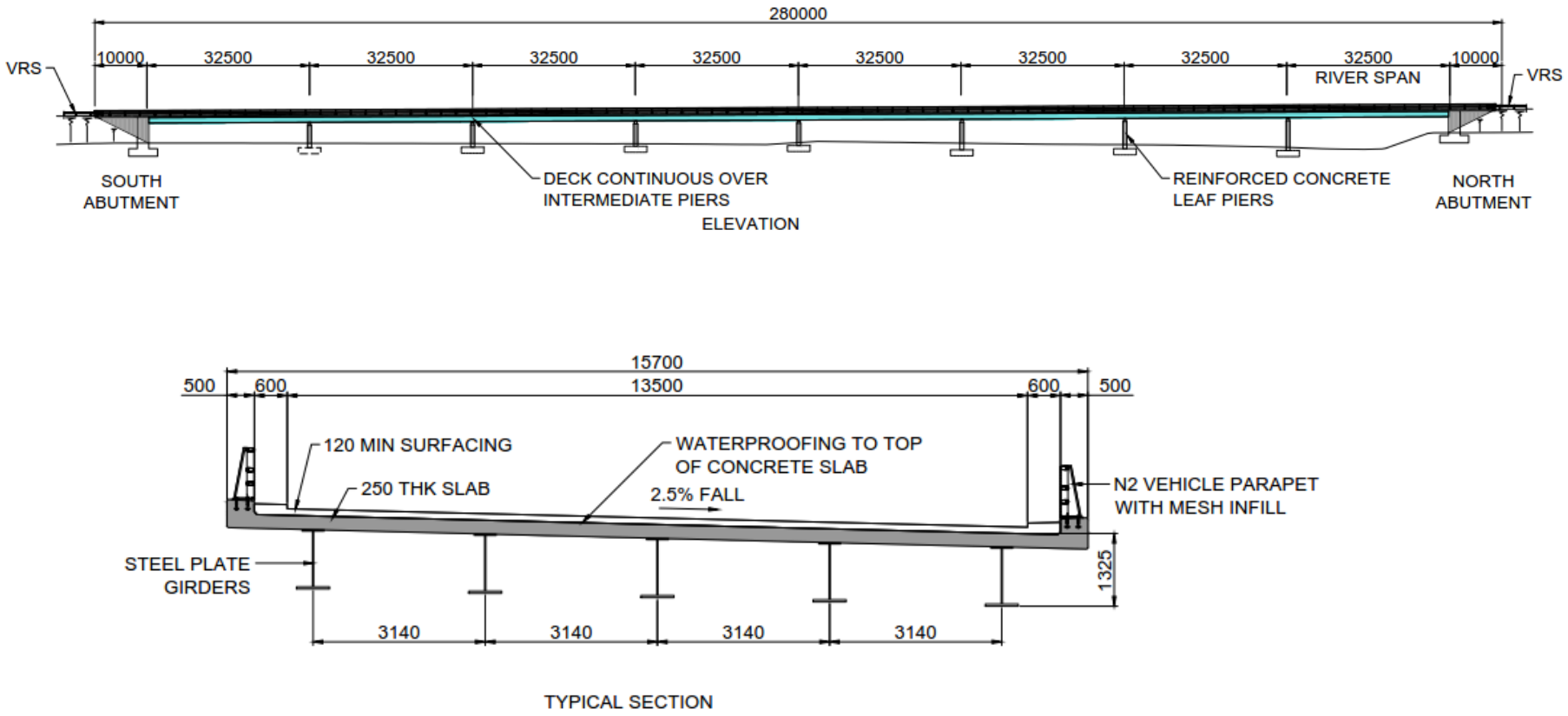


Figure 64 – Option 1 Steel /concrete composite multi-girder deck- Viaduct Elevation, Typical Section.

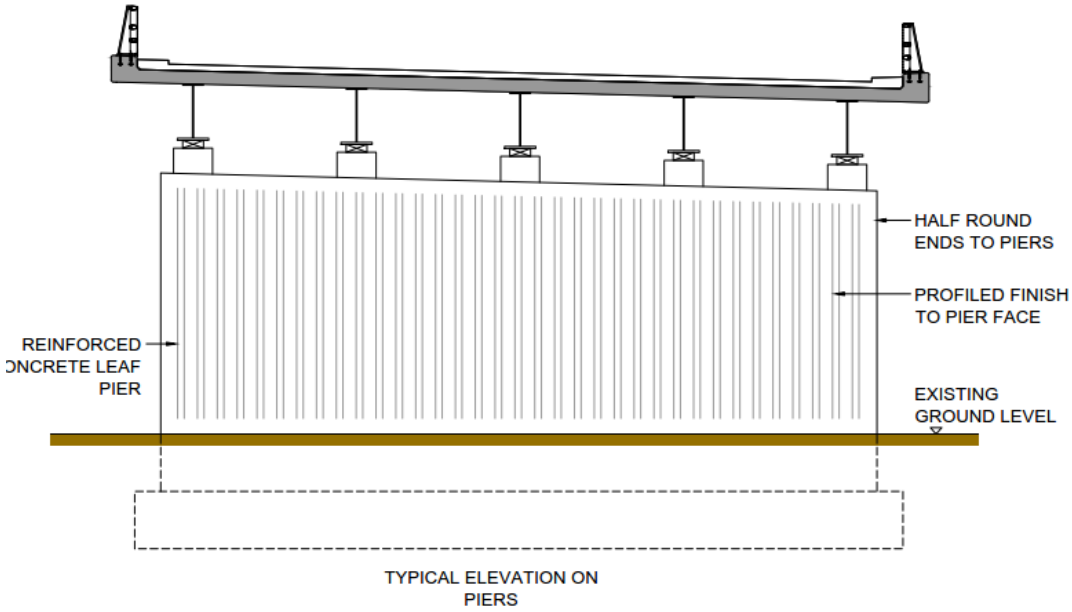


Figure 65 – Option 1 Steel /concrete composite multi-girder deck- Pier Elevation

Outline Construction Sequence

The outline construction sequence would be:

- Installation of suitable temporary works (for example sheet pile cofferdams) for construction of supports either side of Afon Gwyrfai to avoid working in the river channel.
- Construct piled foundations for intermediate piers, abutments and wing walls.
- Construct reinforced concrete leaf piers, abutments and wing walls.
- Install bearings above piers and abutments.
- Deliver steel beams to site and lay down.
- Assemble outer pairs of beams as braced pairs at ground level and attached edge protection.
- Lift braced pairs of steel beams to span 1, extending to splice point in span 2. Lift braced pairs of beams to span 2, extending to splice point in span 3, completing splices. Repeat for all the spans of the viaduct.
- Lift the remaining single girder, stabilised to prevent buckling, in sequence with the braced outer pairs and permanently brace back to the pairs of girders.
- Install permanent formwork to form composite deck soffit between beam top flanges.
- Fix deck reinforcement and pour in-situ concrete deck, typically span regions first followed by pier regions.
- Backfill abutments and wing walls.
- Complete finishes – waterproofing, parapets, kerbs, surfacing, deck end joints, etc.

Aesthetics and Landscape Effects -Family of structures, Open aspect/aesthetics

The structural form provides the least construction depth giving a lighter overall appearance. Furthermore, the contrast between the painted steel beams and the reinforced concrete stringcourse to the deck elevations lead to the provision of an aesthetically superior structure in this low lying location.

Highway Alignment and Earthworks Balance – Impacts beyond the bridge location

Of all of the Options for the viaduct, this structural form provides the least construction depth providing greatest allowance for freeboard in a flood event.

The use of steel beams on a single line of bearings allows a narrow width of leaf pier, which presents a reduced width obstructing flood flows.

Overall Construction Methodology and Approach and Safe by Design

Maintenance of haul route

To permit construction of the viaduct, set down/assembly areas will be established alongside the viaduct location. The haul route will also be maintained alongside the viaduct construction site with a bailey bridge crossing of the Afon Gwyrfai.

Transportable

Fabricated steel beams are relatively lightweight, and can be delivered to site in lengths and spliced on site prior to erection as required.

Previous experience on the A487 Porthmadog Bypass scheme further to the south has indicated that it should be possible to transport braced pairs of beams of length 29m to site. For the spans considered here, individual girder lengths are proposed to be less than at Porthmadog.

It is anticipated that beams will be delivered to the viaduct construction site along the haul route, which would be accessed either from the north where the haul route crosses the existing A487 at the location of the proposed Meifod roundabout or from the south where the haul route ties in with the existing A487 at the Goat roundabout.

Erectable/Buildability & Programme

The bridge form is simple to construct, and is of familiar construction, meaning that erection and completion is usually rapid.

It is anticipated that the steelwork will be erected from the south abutment working north.

Safe to construct

The lifting of braced pairs of beams provides an inherently stable solution. Edge protection can be assembled at ground level prior to erection. Permanent formwork provides a closed soffit for safe working at height for all subsequent construction operations at height.

This arrangement of steel beams considered includes a single, unpaired girder. This girder will need to be braced against adjacent paired girders, which will be landed first, as construction, span by span, proceeds. Simple, familiar, standard-type details all lend themselves to safe construction.

Unauthorised access to soffit

There are bearings at the end abutments, and hence enclosures would be required to prevent unauthorised access to the inspection galleries.

Despite the low lying nature of the viaduct, the shallow construction depth of the viaduct provides more than 3m headroom clearance between ground and beam soffit level. It is not therefore considered necessary to provide deterrent measures to prevent unauthorised access to the bottom flanges.

<u>Durability - Maintenance for future durability</u>

One of the disadvantages of a steel concrete composite superstructure compared with pre-stressed concrete or reinforced concrete alternatives is the need to undertake painting activities through the design life of the bridge. A complete grit-blast and repaint of the structural steelwork will typically be required at approximately 25 year intervals. In addition, a mid-term maintenance intervention will typically be required to address minor breakdown of the protective treatment system and ensure that the 25 year major maintenance cycle is achieved.

This activity will not require any traffic management on the A487 and, owing to the low lying nature of the structure, access to the superstructure steelwork for the grit-blast and repainting activities are anticipated to be from ground level using scaffold towers or MEWPs.

The solution also proposes mechanical bearings above the piers, which would require maintenance painting under the same painting regime as the structural steelwork, and potential replacement at 60 year intervals. The steel beams would be provided with additional jacking stiffeners to facilitate this operation, the jacks located on temporary supports located on the upper surface of the foundation bases.

Environment - Noise, local air quality, greenhouse gas emissions, land-take and transport

Of all of the viaduct options, this structural form provides the fewest transport moves and least visual intrusion associated with the least construction depth.

The relatively slender piers have a lower effect on the flood plain and flood river flows compared with Option 3 by virtue of their smaller volume within the flood plain, and the wider opening for water to flow between pier faces.

Comparative Construction Cost

The comparative cost of the steel/concrete composite Option 1 is £4,172,000.

Comparative Whole Life Cost

The comparative whole life cost of the steel/concrete composite Option 1 is £4,824,000.

6.7.4 OPTION 2 – Steel/concrete composite ladder deck

Description

This comprises:

- Multi span steel concrete composite superstructure with two longitudinal main girders with the deck slab spanning longitudinally between cross beams spaced at 3-4m centres.
- Discrete circular reinforced concrete columns supporting the two main longitudinal girders and reinforced concrete end abutments, incorporating inspection galleries, assumed to be founded on piled foundations for comparison purposes.
- Supported on bearings and continuous over intermediate support columns. Simply supported at end abutments, fixed at the lower southern end.
- Deck joint details would be a fixed joint at the lower southern end with a movement joint at the higher northern end.

In general, ladder decks usually prove to be economical for spans upwards of 35 – 40m, proving especially cost effective on wider decks, although the loading on the two main girders can become very heavy.

The span length proposed for Afon Gwyrfai Viaduct is approximately 32m, less than the 35 – 40m noted above. Coupled with this, the low lying nature of the viaduct relative to the ground and the deeper main girders resulting compared with an equivalent multiple beam deck would give a reduced ground clearance to the structure with the associated risk of unauthorised access to the bridge soffit. Multiple beam decks allows for the beam spacings to be reduced in such situations, whereas ladder decks do not offer this capability.

For the reasons given above, a steel concrete composite ladder deck was not considered appropriate and has not been considered further.

OPTION 3 - Precast pre-stressed beam deck

For the span of 32.5m, a number of standard precast pre-stressed beam options are available. Based on these, the following deck cross sections have been considered: Y beams at 1m beam centres, U beams at 2m beam centres, and W beams at 3m centres. These options are illustrated in Figures 66 to 68 below.

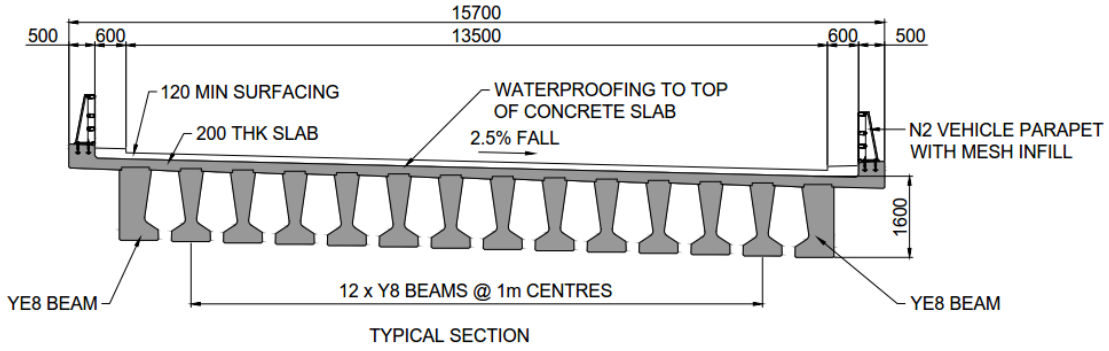


Figure 66 – Option 3 Pre-cast Pre-stressed Concrete Y-Beam Deck Section

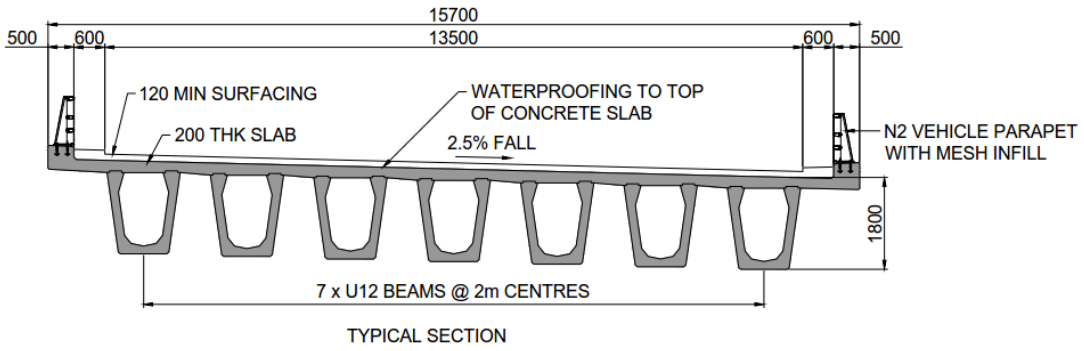


Figure 67 – Option 3 Pre-cast Pre-stressed Concrete U-Beam Deck Section

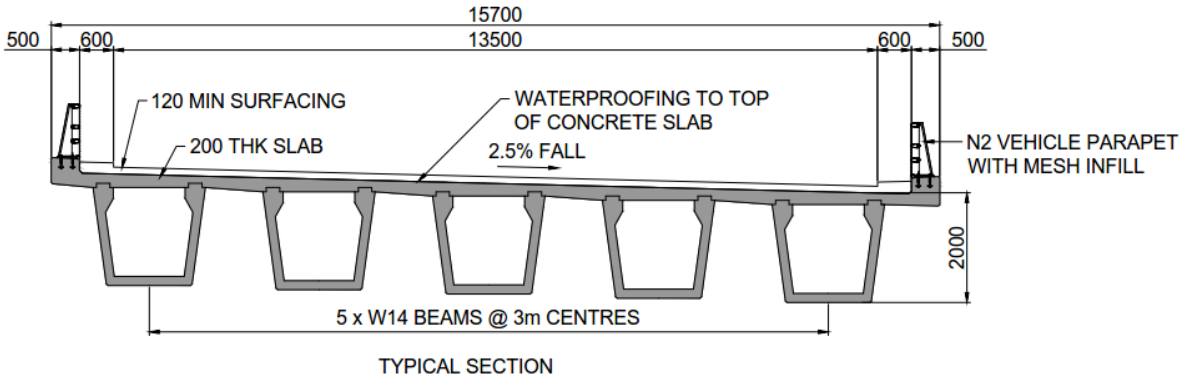


Figure 68 – Option 3 Pre-cast Pre-stressed Concrete W-Beam Deck Section

There is the advantage of the W beam deck over the U beam deck and the U beam deck over the Y beam deck in requiring fewer beams for transportation and erection, but this comes at the disadvantage of increased construction depth and lift weights.

As a result, given the low lying nature of the viaduct and the potential criticality of ensuring sufficient freeboard during flood conditions pending flood modelling, the Y beam deck is considered most appropriate for this location.

The formation of longitudinal continuity at intermediate supports is significant for continuous bridges constructed using precast pre-stressed beams. A number of options are available and have been employed. The options differ in the way that the precast beams are supported prior to making them continuous.

In general, these options can be considered to fall into 2 main categories:

- Wide pier with precast beams temporarily supported on a widened pier;
- Narrow pier with precast beams temporarily supported on temporary propping off the pier foundations.

Options involving “tied slabs” and “continuously separated slabs” have not been considered as there is the risk that of deterioration to inaccessible faces.

These options are illustrated in the Figures 69 and 70 below.

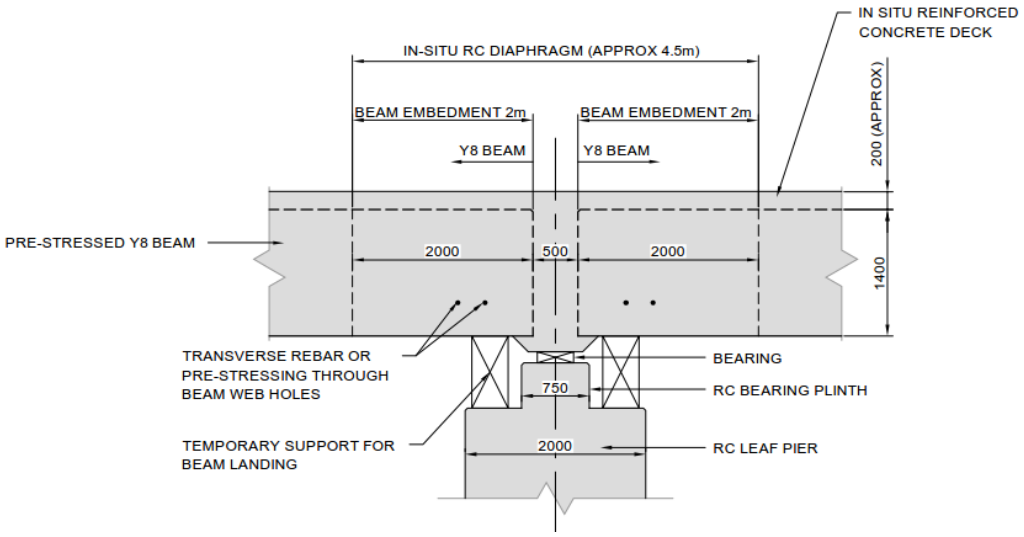


Figure 69. Wide pier with precast beams temporarily supported on widened pier.

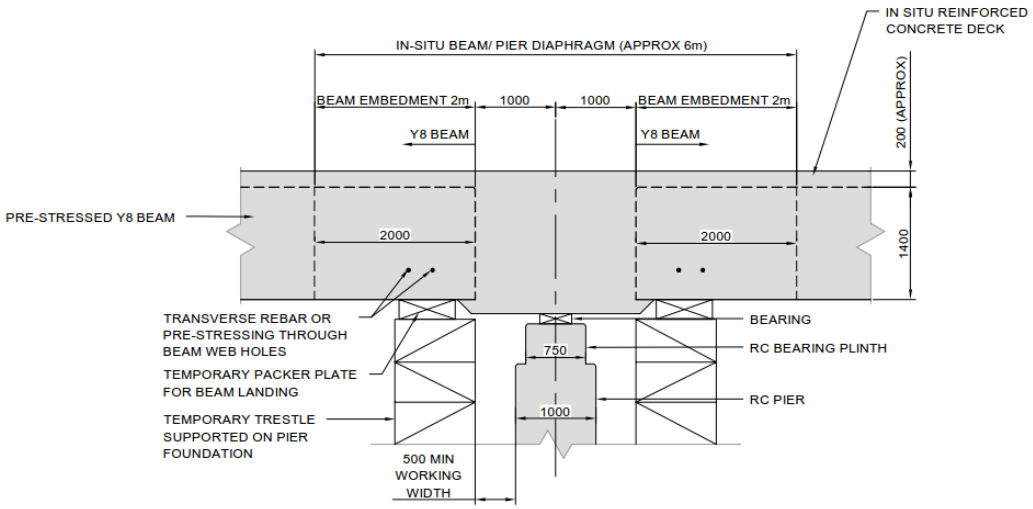


Figure 70. Narrow pier with precast beams temporarily supported on temporary propping.

The principal advantage of the wide pier option is that temporary props are not required since the permanent bearing shelf is of sufficient width.

Description

Option 3 therefore comprises:

- Multi span precast pre-stressed concrete beam superstructure;
- Reinforced concrete leaf piers with rounded ends and reinforced concrete end abutments, incorporating inspection galleries, assumed to be founded on piled foundations for comparison purposes.
- Supported on a single line of bearings and continuous over intermediate piers. Simply supported at end abutments, fixed at the southern end.

- Deck joint details would be a fixed joint at the southern end with a movement joint at the northern end.

Option 3 is illustrated in Figures 71 and 72 below.

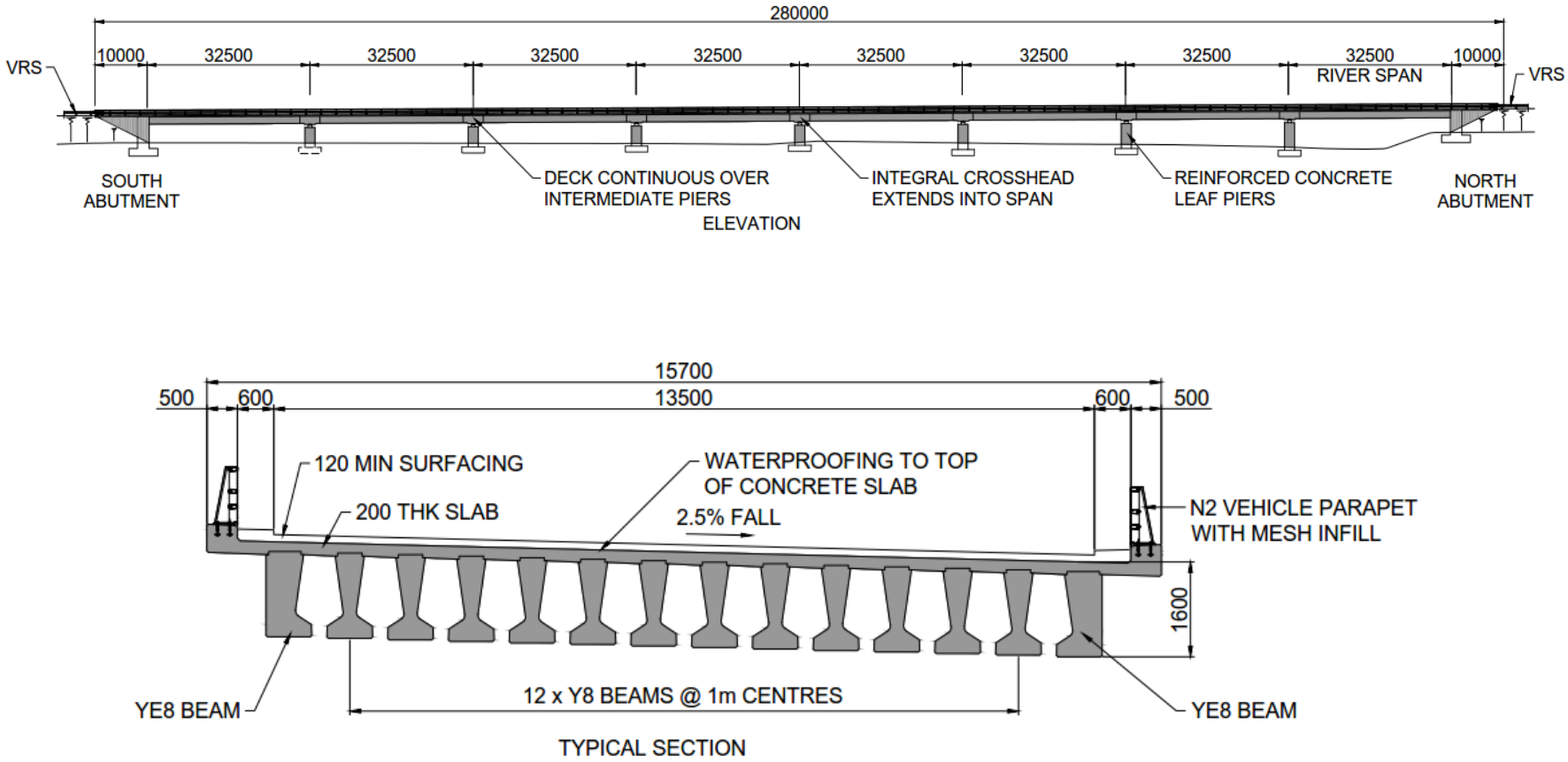


Figure 71 – Option 3 Pre-cast Pre-stressed Concrete Y-Beam deck- Viaduct Elevation, Typical Section.

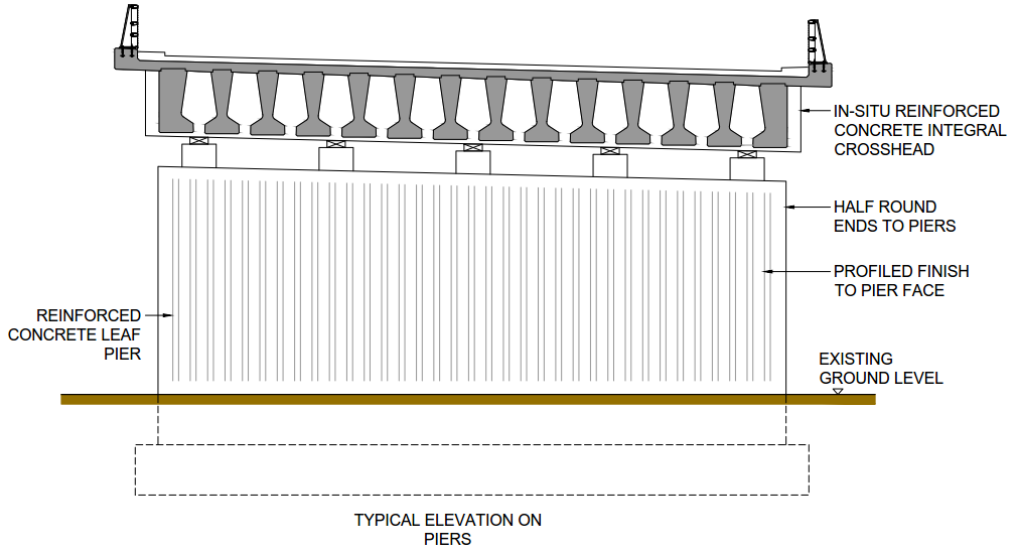


Figure 72 – Option 3 Pre-cast Pre-stressed Concrete Y-Beam deck- Pier Elevation

Outline Construction Sequence

The outline construction sequence would be:

- Installation of suitable temporary works (for example sheet pile cofferdams) for construction of supports either side of Afon Gwyrfai to avoid working in the river channel.
- Construct piled foundations for intermediate piers, abutments and wing walls. Note that larger diameter or an additional number of piles are expected compared with the equivalent steel solution owing to the heavier superstructure.
- Construct reinforced concrete leaf piers, abutments and wing walls.
- Install permanent bearings above piers and abutments.
- Deliver precast pre-stressed beams to site and lift individually onto individual temporary bearings located on the bearing shelves. Edge precast beam to have edge protection attached at ground level prior to lifting. Beams braced together for stability on temporary bearings.
- Erect soffit formwork and formwork between beams for construction of integral crosshead/diaphragm over intermediate supports and diaphragm at end supports. Erect permanent formwork to form deck soffit between beam top flanges.
- Fix reinforcement for crossheads/diaphragms and fix deck reinforcement.
- Pour in-situ concrete crossheads/diaphragms as first stage and deck slab as a second stage of construction of a continuous and composite structure.
- Strip formwork to soffit of integral crosshead/diaphragms over intermediate supports.
- Release structure from temporary bearings onto permanent bearings.
- Backfill abutments and wing walls.
- Complete finishes – waterproofing, parapets, kerbs, surfacing, deck end joints, etc.

Aesthetics and Landscape Effects -Family of structures, Open aspect/aesthetics

The structural form provides a greater construction depth compared with the steel/concrete composite option, which, given the low lying location, will give a heavy appearance to the viaduct. In this respect, this option is considered to be inferior aesthetically to the steel/concrete composite Option 1.

Highway Alignment and Earthworks Balance – Impacts beyond the bridge location

This structural form provides a greater construction depth than the steel/concrete composite Option 1, reducing the allowance for freeboard in a flood event.

Furthermore the wider piers, required to support temporarily the beams during construction, will present a greater width obstructing flood flows. As noted earlier, providing wider piers to temporarily support the beams during construction of continuity is considered preferable to narrower piers and more extensive temporary works to support the beams.

The wider pier may also result in the tops of the piers being set at a lower level with the bearing plinth heights increased in order for the bearings themselves to be accessible for inspection and maintenance. This may result in an increased risk of flood debris accumulating on the tops of the piers along the bearing shelf if the pier

tops fall within the 600mm freeboard. This will not be known for certain until the flood modelling, currently in progress, has been completed.

Overall Construction Methodology and Approach and Safe by Design

Maintenance of haul route

To permit construction of the viaduct, lay down areas will be established alongside the viaduct location. The haul route will also be maintained alongside the viaduct construction site via a temporary bailey bridge crossing of the Afon Gwyrfai.

Transportable

Precast pre-stressed beams weigh significantly more than fabricated steel beams (48 tonnes for Y8 beams, 61 tonnes for U12 beams and 80 tonnes for W14 beams), and unlike steel beams cannot be delivered to site in short lengths and spliced on site prior to erection.

Preliminary enquiries with a precast beam supplier and a haulier have indicated that it should be possible to transport precast beams of 32m length to site. Removal of some street furniture, e.g. traffic signs and lamp posts, may be required to negotiate part of the route from the A55 at Bangor to the viaduct site. In addition, it may be necessary to travel the “wrong way” along part of the route through Caernarfon town centre under escort and at night. Given that the route is via A-roads, no issues with the weights of beams and hence vehicle axle weights have been foreseen.

It is anticipated that beams will be delivered to the viaduct construction site along the haul route, which would be accessed either from the north where the haul route crosses the existing A487 at the location of the proposed Meifod roundabout or from the south where the haul route ties in with the existing A487 at the Goat roundabout.

Erectable/Buildability & Programme

The bridge is significantly more complex to design and construct than the equivalent steel structure owing to the need to provide continuity between the ends of the precast pre-stressed beams over the intermediate pier supports.

With the integral crosshead/diaphragm having to accommodate longitudinal as well as transverse load effects, reinforcement can become congested and difficult to detail and therefore difficult to fix on site. Projecting bars or strand from the ends of the precast beams, provided to resist longitudinal sagging moments as a result of creep and shrinkage, further complicate reinforcement fixing.

There are more stages in the construction of the longitudinal continuity compared with steel, with the need for the beams to be supported on temporary bearings and additional stages of reinforcement fixing and placing concrete to integral diaphragms and deck slabs. Much of this work would also be carried out at height from scaffolding placed around the pier tops.

As result of the above complexity, it is anticipated that construction of the viaduct would be much less rapid than the steel viaduct.

It is anticipated that the precast beams will be erected from the south abutment working north.

Safe to construct

The lifting of edge beams with cantilever formwork in place to provide edge protection is typically inherently unstable during erection. Precast concrete stringcourses could be utilised in lieu of an in-situ stringcourse to mitigate such instability during erection. However, temporary works are typically required between all beams to stabilise them against over-turning during construction.

Permanent formwork provides a closed soffit for safe working at height for all subsequent construction operations at height.

The provision of continuity between longitudinal beams also requires for greater amount of working at height from scaffolding placed around the pier heads than the equivalent steel option.

Unauthorised access to soffit

There are bearings at the end abutments, and hence enclosures would be required to prevent unauthorised access to the inspection galleries.

Precast pre-stressed beams do not provide ledges and handholds to the extent of steel and notwithstanding the construction depth being greater than for steel and hence the clearance between ground and beam soffit level being reduced, unauthorised access to the soffit of the viaduct is not considered to require any deterrent measures.

Durability - Maintenance for future durability

With no structural steelwork to paint, a precast pre-stressed beam superstructure provides a significant advantage compared with the steel/concrete composite alternative in terms of future maintenance liability.

Precast pre-stressed beams are manufactured in a factory under controlled conditions to a consistently high quality such that maintenance in the form of concrete repairs in the future is unlikely.

The use of permanent formwork to the deck soffit also means that these surfaces will be protected from environment degradation.

Notwithstanding the reduced maintenance requirements of the concrete superstructure, this solution does however propose mechanical bearings above the piers, which would require a maintenance intervention in their own right for painting and potential replacement at 60 year intervals. A mid-term maintenance intervention will typically be required to address minor breakdown of the protective treatment system to ensure that the 25 year major maintenance cycle is achieved.

Environment - Noise, local air quality, greenhouse gas emissions, land-take and transport

Compared with the steel/concrete composite option, this structural form requires a greater number of transport moves, particularly for the Y beam deck. These could potentially be more disruptive to the existing road network should temporary closures or diversions be required in order to accommodate deliveries. The delivery of such beams is also more disruptive to the local environment and communities in that the longer lengths of beams to be delivered means that street furniture would potentially require removal temporarily along the route to site.

Whilst the use of fewer, larger beams (U and W sections) would reduce the numbers of beams to be delivered, the significant increase in beam weight would require larger vehicles with more axles along the existing road network.

Comparative Construction Cost

The comparative cost of the precast pre-stressed concrete beam superstructure Option 3 is £5,010,000.

Comparative Whole Life Cost

The comparative whole life cost of the precast pre-stressed concrete beam superstructure Option 3 is £5,043,000.

6.7.5 OPTION 4 – In situ reinforced concrete slab deck

Description

This comprises:

- Multi span in situ reinforced concrete slab deck superstructure.
- Reinforced concrete leaf piers with rounded ends and reinforced concrete end abutments, incorporating inspection galleries, assumed to be founded on piled foundations for comparison purposes.
- Supported on a single line of bearings and continuous over intermediate piers. Simply supported at end abutments, fixed at the southern end.
- Deck joint details would be a fixed joint at the southern end with a movement joint at the northern end.

Reinforced concrete solid slab decks are one of the simplest forms of bridge deck. Ease of construction resulting from this simplicity makes this the most economic type for short span bridges. Solid slabs also have good distribution properties and unlike in bridges built from precast beams, it is no more complicated to build a continuous bridge than one which is simply supported.

However, above a span of around 10m, the effect of permanent actions starts to become excessive, making other forms of construction more economic, i.e. voided slab. Even so, this form of construction is only likely to extend the economic range of this type of structure to around 16m, and purely reinforced concrete structures longer than 20m span are quite unusual.

Notwithstanding that even based on a 20m long span, such a structure form for the Afon Gwyrfai would be unable the span the river channel, the number of intermediate supports required would increase to twelve compared with the seven required for the 32.5m long span arrangement.

For the reasons given above, an in situ reinforced concrete slab deck was not considered appropriate and has not been considered further.

6.7.6 Summary of Comparative Capital Works Costs for Conforming Design Viaduct Options

A summary of the comparative capital works costs for the viaduct options based on the conforming design is presented in the table below.

	Superstructure Materials			
Span arrangement	Steel concrete composite multi-beam deck	Steel concrete composite ladder deck	Pre-cast pre-stressed concrete beam deck	In-situ reinforced concrete deck
8No 32.5m Spans	**Option 1**	**Option 2**	**Option 3**	**Option 4**
Capital Cost	£4,172,000	N/A	£5,010,000	N/A

6.7.7 Summary of Comparative Whole Life Costs for Conforming Design Viaduct Options

A summary of the comparative whole life costs for the viaduct options based on the conforming design is presented in the table below.

	Superstructure Materials			
Span arrangement	Steel concrete composite multi-beam deck	Steel concrete composite ladder deck	Pre-cast pre-stressed concrete beam deck	In-situ reinforced concrete deck
8No 32.5m Spans	**Option 1**	**Option 2**	**Option 3**	**Option 4**
Whole Life Cost	£4,824,000	N/A	£5,043,000	N/A

6.7.8 Recommendation for Conforming Viaduct Design Solution

Based on the summary of comparative capital and whole life costs:

- Option 1, a steel composite multi-beam deck, provides the lowest capital works cost solution.
- Option 1, a steel composite multi-beam deck, provides the lowest whole life cost solution.

In addition, Option 1 has significant construction advantages over Option 3.

On the basis of the provision of a minimum comparative capital works and whole life cost structure, and on the basis of the review of the proposed structural forms against the Context for Structures and Other Factors Affecting Choice identified in Sections 4 and 5 of this report, respectively, it is recommended that Option 1, an eight span steel composite multi-beam deck, be adopted for Structure S106 Afon Gwyrfai Viaduct (WG Asset Number A487 581) as the conforming design to meet the mandated requirements for the structure.

6.7.9 Refinement of Option 1 Conforming Design solution

Based on the outcome of the comparison exercise above, Option 1 for the Conforming Design has been reviewed and finessed against the various constraints for which further information has been determined as Key Stage 3 has progressed.

Based on information from the topographical survey undertaken during Key Stage 3, the actual river channel location through the northern-most span is in a slightly different location to that depicted on the Ordnance Survey data. The proximity of the river meander to the pier immediately to the south of the river was perceived to be a significant risk to the solution, both in terms of constructability in close proximity to the SAC, and in terms of the hydro-geomorphological development of the river meander

and the need to provide bank protection – see Figure 73 below, and the clouded areas.

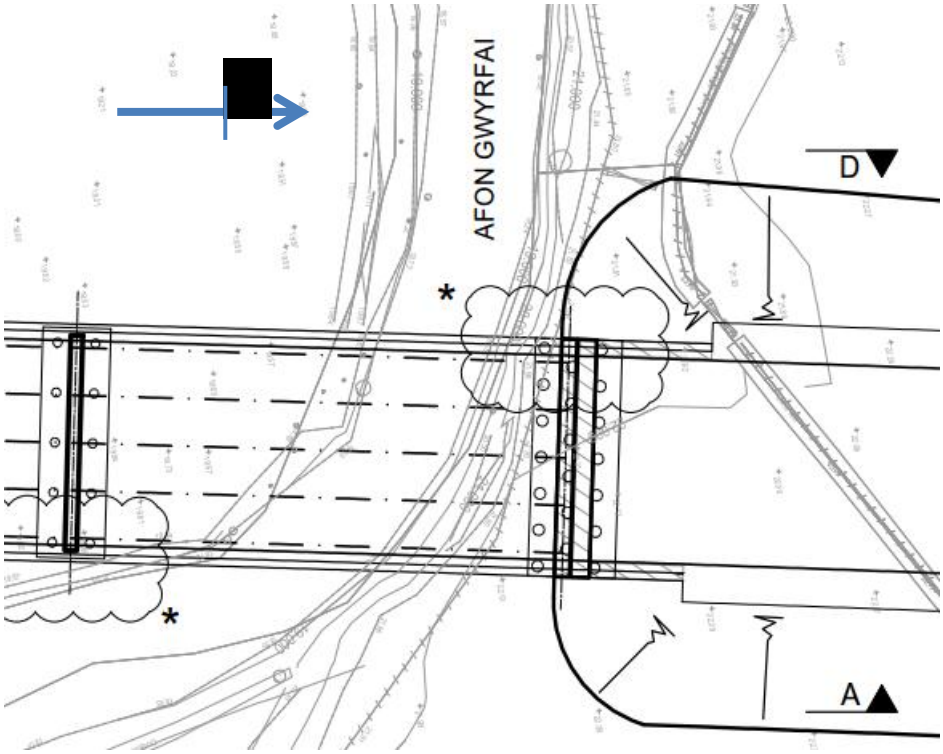


Figure 73 – Pier foundation clash with SAC following receipt of topographical survey information

As a result of the above, the highway alignment has been moved approximately 10 metres west. The resulting amendment to the highway alignment has resulted in a significantly improved solution for the northern span, as depicted in Figure 74 below:

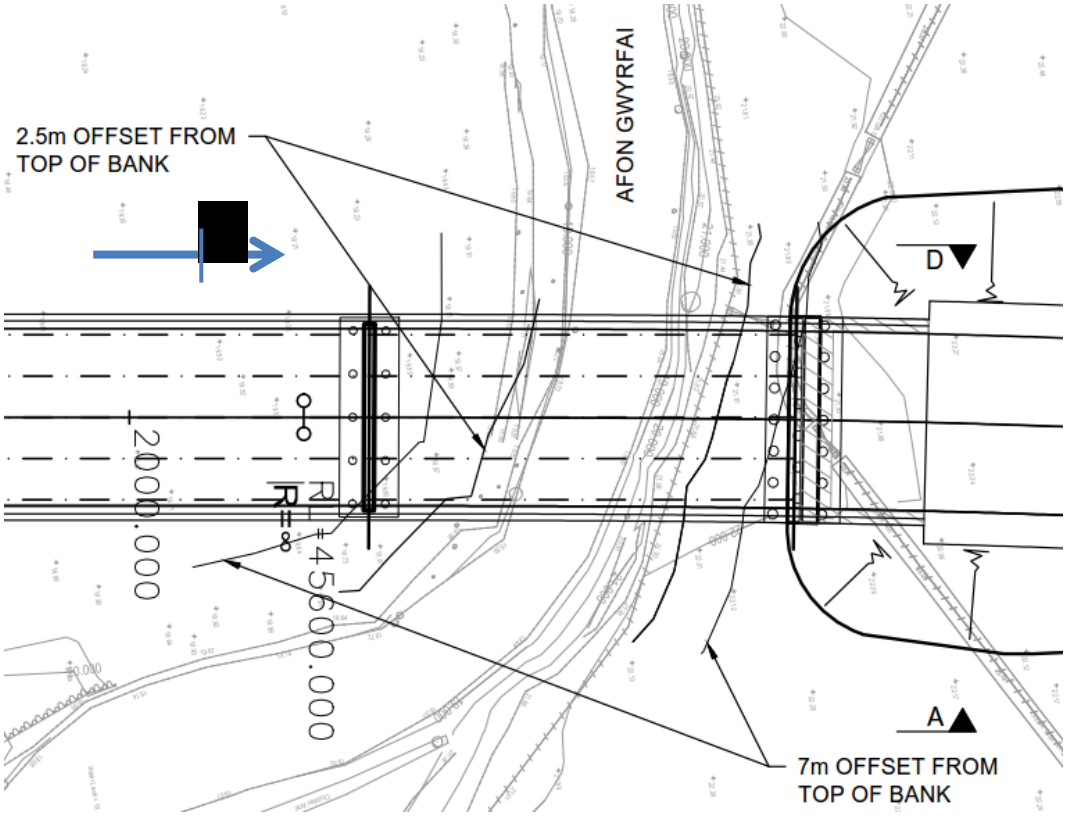


Figure 74 – Pier foundation remote from SAC following highway re-alignment

This has provided a solution for which a significantly increased lateral clearance to the SAC, particularly for construction of pier foundations, can be achieved. It also presents a solution where a lateral clearance of greater than 7 metres is typically provided between the substructure faces and the top of the river bank to assist with river maintenance, with only very local pinching of this dimension down to a minimum of approximately 5.8m at the points where the abutment and pier corners are closest to the river.

The amended A487 horizontal alignment has also removed the 7000m plan radius curve from the structure. Six of the eight spans are now below a straight highway horizontal alignment. The two northern-most spans are located below a horizontal transition into a right hand curve, but the lateral shift associated with the transition is minor (approximately 180mm) within the length of the structure. This has the distinct advantage of being able to keep the steel beam alignment straight for the whole length of the structure, greatly easing fabrication and erection, with the transition curvature then accommodated through a minor change in the deck edge cantilever widths in the two northern-most spans. It may be possible to further refine the transition location during future highway alignment design to further reduce its impact on the structure.

Also from the actual topographical survey, existing ground levels across the floodplain below the viaduct are such that:

- More than 3m headroom clearance is provided along the whole length of the Conforming Design.
- A headroom clearance of 4.5m can be achieved throughout the whole of the length of the viaduct span south of the river, thereby facilitating farm accommodation access between field areas to each side of the viaduct.

Base-line flood modelling has been undertaken for the existing River Gwyrfai. This has revealed that maximum 1 in 1000 year flood levels at present in the location of the viaduct are approximately 20.42m AOD – see figure 75. Following completion of the scheme, if Option 1 were to be constructed, then maximum 1 in 1000 year flood levels as modelled would be approximately 20.6m AOD.

Option 1 provides a solution with steel beam soffit levels at a minimum level of approximately 23.7m AOD. From this, it can be seen that the proposed Option 1 provides a freeboard very much in excess of the 600mm minimum required.

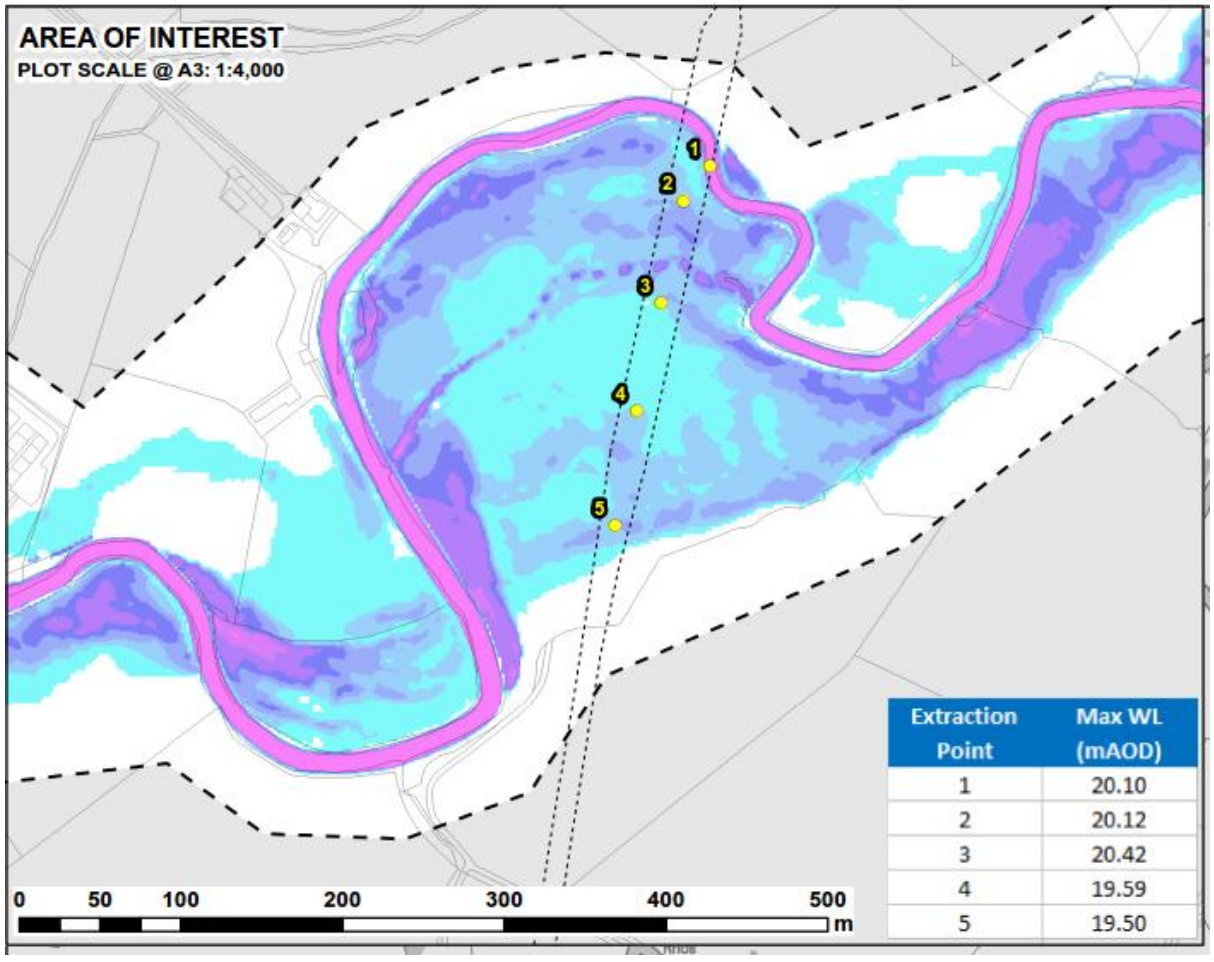


Figure 75 – Abstract from baseline flood model Drg W3172-GWY_Q1000_EXG_D Rev A at proposed viaduct location – 1 in 1000 year flood

On the basis of the refinement exercise described above, it is still recommended that Option 1, an eight span steel composite multi-beam deck be adopted for Structure S106 Afon Gwyrfai Viaduct (WG Asset Number A487 581) as the conforming design to meet the mandated requirements for the structure.

The General Arrangement for the structure, based on the recommended Option 1, is contained in Appendix D.

6.8 S106 Afon Gwyrfai Viaduct (WG Asset Number A487 581) – VE Design

6.8.1 Introduction

The flood modelling was developed to assess the effects on flood risk of the Conforming Design and its associated structure length.

A Value engineering (VE) opportunity has been recognised to potentially reduce the mandated length of viaduct for the above structure.

Potential VE options that have been considered are as follows:

i VE Option 5 - Reduce structure length and replace with impermeable embankment.

ii VE Option 6 - Reduce structure length and replace with permeable embankment (constructed from granular material).

iii VE Option 7 Reduce structure length and replace with embankment perforated with pipes/culverts.

All such VE solutions have the potential to increase the level of flood water within the valley, and hence the risk of flooding to stakeholders.

VE Option 5 has been tested within the base-line flood model in order to evaluate the potential effects and hence the risks associated with this VE proposal.

6.8.2 VE Option 5 Results

Flood modelling work has been undertaken to evaluate the effects on both the flood plain and flood levels of replacing part of the southern section of the conforming 8 span steel composite viaduct with impermeable embankment.

For the purposes of evaluation, flood modelling work has assumed the removal of an incremental number of spans from the southern end of the viaduct – models have been developed to test removal of 2, 3 or 4 complete viaduct spans and replacement with embankment.

From the flood modelling results, it would appear feasible to replace the 3 no. southern spans of the viaduct with an embankment, thereby giving rise to a 5 span steel composite viaduct. Additional flood culverts may be required to pass through the embankment placed into the floodplain, along with other mitigation measures such as erosion protection and some local ground re-profiling in the vicinity of the structure.

The VE Option 5 proposal now requires substantiation through further design and stakeholder consultation, and if still considered feasible, may be developed through the remainder of Key Stage 3 as the preferred option.

6.9 S112 River Seiont Viaduct

6.9.1 Introduction

The A487 mainline is proposed to cross the Afon Seiont and its valley to the south west of Caernarfon on viaduct.

The valley is characterised by shallow side slopes to the south extending into the floor and flood plain with the river channel cut a further 2-3 metres before the ground rises very steeply to the north with a height of slope approaching 20m.

The proposed mainline crosses the Afon Seiont at the same point as the course of the dismantled alignment of the former Caernarfon and Llanberis Railway and the railway embankment remains.

The Glan Gwna Holiday Park is situated on the line of the proposed viaduct and extends to the east and south along the banks of the Afon Seiont, covering over 120 acres and comprises private caravans and lodge holiday homes. The holiday park owner has been identified as a significant external stakeholder in the development of the scheme.

The A4085, Waunfawr Road, from Caernarfon to Beddgelert crosses the proposed mainline towards at the southern end of the valley.

From an ecological perspective, the valley, particularly the northern side, offers a range of broadleaf woodland and scrub habitats. The river also provides habitats for otters and water voles. Dormice and badgers are also known to be present and the valley is located on bat commuting routes.

The proposed mainline alignment at the location of the viaduct is located on a 510m radius horizontal curve to the right (i.e. looking north). This gives rise to a 7% super elevation and hence cross fall across the carriageway which the bridge deck cross section will be required to follow to avoid unnecessary thickening of the deck structure. The horizontal plan curve also gives rise to the need to provide a widened verge of 3.6m width of the inside (east side) of the curve in order to meet the requirements for forward visibility.

The vertical alignment of the mainline comprises a straight gradient rising from south on embankment approximately 5-6m above existing ground level to north such that the alignment enters the steep valley side at the north end part way up the slope, and is in slight cutting at the top of the slope extending from this point heading north.

Key Stage 2 works

At Key Stage 2, the structure length, level and carriageway cross section were contained within mandatory budget assumptions.

Topographical survey information was based on Ordnance Survey data with a relatively low level of resolution and hence ground levels could vary by 1-2 metres from the actual ground level which would only be confirmed by detailed topographical survey proposed at Key Stage 3. This was particularly considered to be a risk for the level of the A4085 where it is required to pass under the proposed viaduct and for the position and form of the abutment and intermediate pier foundations at the northern end of the viaduct which would likely be located in the steep slope. The absence of any information on ground conditions at Key Stage 2 increased further the uncertainty associated with the viaduct foundations at the northern end.

Whilst not anticipated to be as critical for the Afon Seiont, unlike the Afon Gwyrfai, no hydrological modelling had been undertaken at Key Stage 2 to understand flood

levels and the effect of the construction of the viaduct on the flood plain. Similarly for the Afon Gwyrfai, there had only been limited discussions with statutory organisations.

Key Stage 3 works

With numerous highway design iterations for both the A487 main line and side roads, ground investigation works, topographical survey works, flood modelling, iterations for earthworks to achieve a cut fill balance, Public Information Exhibitions and other stakeholder liaison, all progressing in parallel during the early part of Key Stage 3, and with any recommendations informing the scheme structures content then coming near the end of the programmed period for production of the Design Options Reports, there have been many challenges in providing a number of options for this particular viaduct for an evolving design in a restricted programme.

The approach taken, again, has therefore been to develop likely solutions appropriate to the numerous constraints for comparative purposes, and apply and refine the outcome of this work to meet the specific details and constraints at the structure location which have crystallised out of the design process following receipt of topographical survey information, ground investigation information, flood modelling outputs, stakeholder feedback, freezing of the highway alignment, etc.

Key constraints at this location which have informed the development of a number of options for comparison purposes include:

- Mandatory budget assumptions regarding viaduct length, carriageway cross section and level.
- The plan location and extents of the flood plain to the Afon Seiont.
- Provision of 600mm freeboard above maximum flood level (readily achieved by virtue of the height of the viaduct);
- WG TAA requirement for 3.0m soffit clearance to ground level to prevent unauthorised access to soffit elements where hand-holds can be gained.
- Provision of a passage around the substructures to facilitate river maintenance access along the river banks.
- Restricted access for construction into the river valley.
- The plan 510m radius curvature of the highway alignment across the viaduct.
- The significant super-elevation of the highway alignment across the viaduct.

Position of North Abutment

Notwithstanding the above, at the outset of Key Stage 3, it was noted that the Key Stage 2 illustrative design drawing indicated the superstructure of the viaduct extending a considerable distance into and beyond the face of the north slope of the valley, to the extent that a large cutting would have to be created within the slope and extending towards high chainage to accommodate the north abutment. This is illustrated in Figure 76 below.

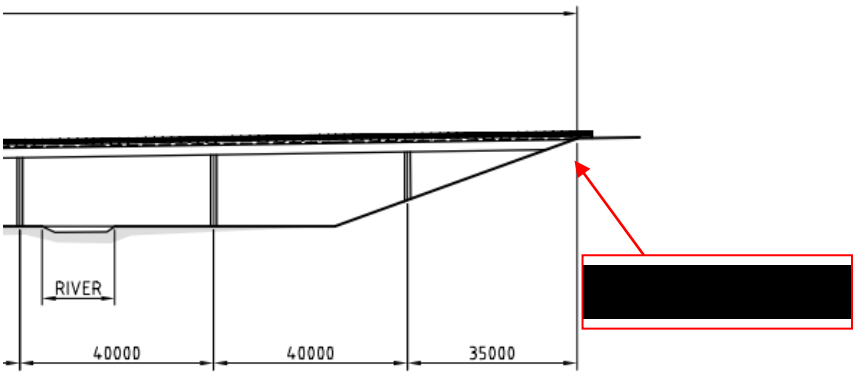


Figure 76. Extract from Key Stage 2 illustrative design drawing showing position of north abutment of Afon Seiont Viaduct.

It has been recognised through design development that this unconventional arrangement could be mitigated through amending the position of the northern end of the viaduct such that the abutment is situated more conventionally closer to the face of the existing slope, as illustrated in Figure 77 below.

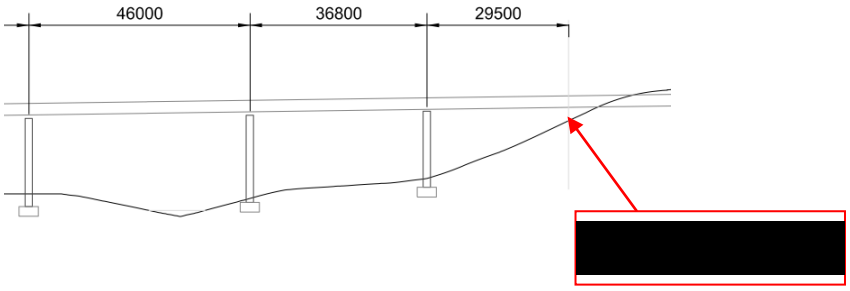


Figure 77. Revised location of north abutment moved to face of slope.

This involved moving the north abutment by approximately 40m towards low chainage, with the associated translation of the whole mandated viaduct length.

Further design development has recognised that this translation of the viaduct to the south would result in superfluous viaduct length to the south of the A4085 and hence the opportunity has been taken to reduce the overall viaduct length to 260m.

This arrangement was deemed to represent a more appropriate solution for the location, and hence was used initially to define the length of the viaduct for the purposes of preparation and comparison of options for span arrangements and construction materials.

For the purposes of this report, the options considered to deliver a structure complying with the above will hereinafter be referred to as the Conforming Design.

6.9.2 Span arrangements and choice of construction materials

Conforming Design

As described above, the viaduct structure length considered is 260m measured from abutment face to abutment face, to extend across the valley floor.

Given the height of the structure, particularly at the north end, span arrangements have sought to reduce the number of intermediate support piers required, and hence spans in the range of 40 to 50m are deemed appropriate – the Key Stage 2 illustrative design indicated 40m long main spans.

Unlike the Afon Gwyrfai crossing, the large spans proposed for the Afon Seiont Viaduct mean that spanning the river channel is unlikely to require span lengths any higher than those already proposed. However, consideration will be required in the siting of piers (and their foundations) either side of the river to avoid the river channel itself. The Afon Seiont does not share the same environmental designations as the Afon Gwyrfai i.e. Special Area of Conservation which is limiting the position of foundations and hence span lengths in that instance, although there are ecological constraints as noted above.

The combination of the mandated carriageway level across the viaduct, the proposed construction depth of the viaduct (consistent with the span arrangement depicted in the Key Stage 2 illustrative design) and, as noted above, the relatively coarse topographical survey meant that there was a risk of not being able to span the A4085 with standard headroom clearance provision.

The approach that has been adopted is thus to provide a structure form for the span over the A4085 having reduced construction depth in order to provide standard headroom and/or avoid significant lowering of the A4085.

Henceforward, the basis for options for the Afon Seiont Viaduct considers a different structure form for the span over the A4085 compared with the remainder of the viaduct crossing the Afon Seiont and the valley floor. This arrangement was deemed to meet with the mandatory budget requirements, as confirmed in the Welsh Government TAA TWG held on the 29th January 2015.

A4085 Span

The clear span required for the structure to carry the mainline across the existing A4085 has been based on providing a 6.5 wide carriageway, to match existing, with a 2m wide verge on the south side and a 1.2m wide verge on the north side, giving a clear span between the faces of the abutments of 9.7m. The existing road does not have verges on either side.

The proposed 2m wide verge on the south side will also accommodate the proposed diversions of footpaths FP31 and FP32.

Span arrangements, choice of construction materials and safe by design

It is proposed that access for construction of the bridge would be gained along the A4085, the steepness of the north slope of Afon Seiont valley precluding access along the A487 haul route for heavy plant and machinery, e.g. cranes and piling rigs.

For the bridge itself, it is proposed that the bridge is constructed on line with the existing A4085 to avoid any significant vertical or horizontal realignment of the A4085 and statutory undertakers' apparatus within the highway. Structures design options considered seek to minimise the impact on operation of the A4085 during construction through the use of pre-cast or prefabricated superstructure elements which can be quickly lifted into place above the highway to create a closed soffit for ensuing construction activities.

Substructures are to be located at a sufficient distance from the existing road alignment to allow them to be largely constructed whilst the road is open normally and avoiding significant diversion of statutory undertakers' apparatus. This may require an increase in the 9.7m minimum span of the highway cross section noted above to

facilitate. It is accepted that temporary closures or traffic management may be required in order to undertake certain construction operations.

If the A4085 span were considered as a stand-alone structure, the site geometry and constraints lend themselves to consideration of either a 3 span or single span underbridge solution, with either steel concrete composite or pre-stressed concrete beam superstructures.

However, given that the opening is considered part of the larger Afon Seiont crossing, 3 span solutions are not considered appropriate, considering the proximity of the end support at the southern end of the main viaduct structure

Hence, a summary of the options applicable at this location are summarised in the table below:

	Superstructure Materials			
Span arrangement	**Steel concrete composite multi-beam deck**	**Steel concrete composite ladder deck**	**Pre-cast pre-stressed concrete beam deck**	**In-situ reinforced concrete deck**
Single span superstructure Reinforced soil abutments Reinforced concrete abutments	Option 5	Option 6	Option 7	Option 8

Description and consideration of the various options set out in the table above has already been presented in the Overbridge section of this report using the same option numbers, and the salient points and summaries are also applicable to the span over the A4085.

From the work undertaken for Overbridges, it is concluded that the optimum solution at this location comprises Option 7. Option 7 comprises a pre-cast, pre-stressed concrete beam deck, either supported on reinforced soil abutments or, alternatively, supported on integral reinforced concrete abutments. Both variations are as described in the Overbridge section above and therefore the detail will not be repeated here. However, the applicability of Option 7 to the actual bridge site is set out below.

Applicability of Option 7 Alternatives to A4085 Location

For the 9.7m clear span solution, Option 7 provides an appropriate solution.

A single span underbridge at this location is also consistent with other underbridges along the scheme, so maintaining a family principle in terms of underbridge form.

A pre-cast, pre-stressed concrete superstructure on either form of substructures offers a low maintenance solution.

The relatively short span lends itself to a shallow construction depth using TY and TYE pre-cast, pre-stressed concrete beams which, when in-filled and topped with in-situ concrete, create a robust and durable solid slab deck superstructure. The advantage of such a deck form is that it creates a closed superstructure immediately upon landing the beams which, when sealed, allow superstructure construction activities to continue over the highway largely unhindered by the presence of the highway below.

In terms of substructure options, the proximity of the proposed southern end support of the main viaduct structure to the proposed north support to the A4085 span means that this is likely to be a shared substructure, akin to a “king pier”, and therefore likely to preclude the use of reinforced soil, due to the interaction between the two sets of ends supports and the space available to install the required length of reinforcing straps. Hence, the preferred form of substructure comprises conventional reinforced concrete inverted tee abutments.

The preferred form of structure for the A4085 span is illustrated in Figures 78 and 79 below.

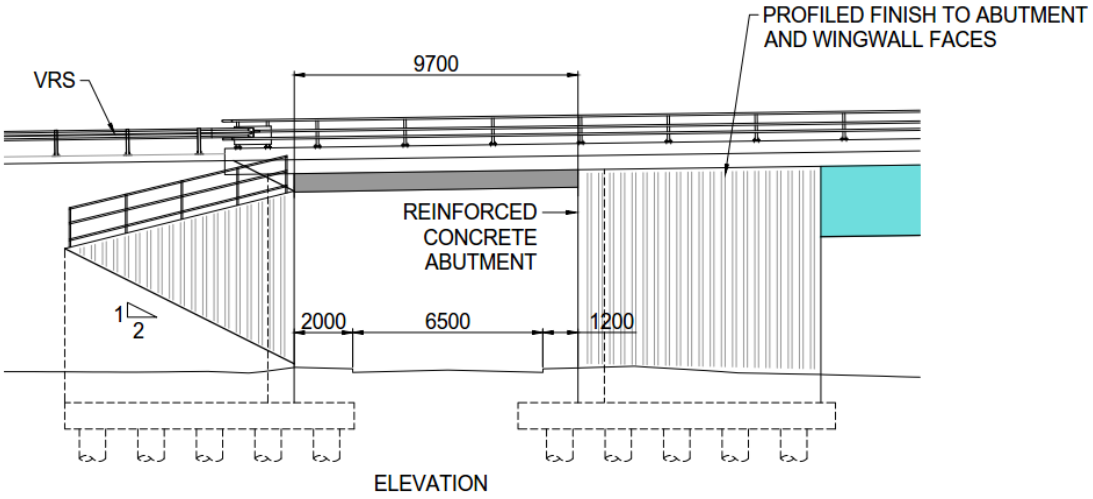


Figure 78. Elevation depicting reinforced concrete substructures

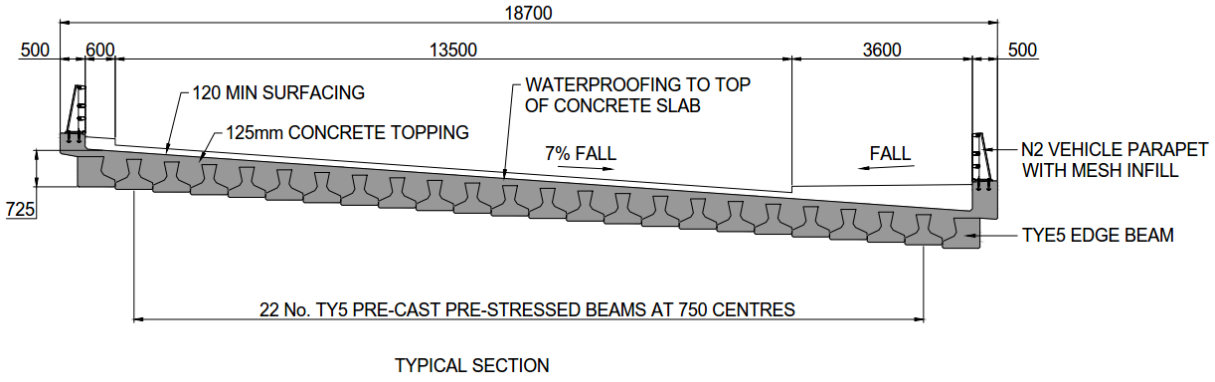


Figure 79. Superstructure cross section

Main Viaduct

Options for the main viaduct superstructure consider continuous spans, with fixed bearings longitudinally at the southern end.

Articulation for all viaduct options is similar. Expansion and contraction would be designed to take place about a single fixed point at the southern abutment, with mechanical guided bearings along one side of the viaduct set out radially from the fixed point. All other bearings would be mechanical free bearings.

As noted previously, the road vertical alignment rises from south to north with the height of the viaduct above ground level increasing to approximately 15m above the river. Options for intermediate support piers have not considered reinforced concrete leaf piers due to the increased visual impact and large volume of material required to construct such substructures. Options have instead considered discrete columns or Y-shaped piers, as appropriate for the form of superstructure.

At each end of the viaduct, abutments will be provided with inspection galleries to provide full touching distance access to bearings.

Access for inspections is assumed to be similar for all options, either via:

- A lorry-mounted underbridge unit positioned on the 3.6m wide raised verge to the east side of the viaduct and protected by appropriate traffic management;
- Roped access by a specialist inspection company;
- MEWPs located on areas of firm ground below the viaduct.

Construction Materials

Notwithstanding, the length of viaduct, the options for superstructure type are considered to be equivalent:

- Steel /concrete composite multi-girder deck;
- Steel/concrete composite ladder deck;
- Steel/concrete composite box girder deck;
- Precast pre-stressed concrete beam deck;
- Post-tensioned concrete deck.

Each of the deck options identified above is briefly described below. Principal element sizes have been typically determined from a combination of preliminary sizing exercises, use of available look-up tables and/or manufacturers' data sheets, blended with experience of similar structural forms on other highway schemes.

For each of the options, consideration has been given to:

- Outline construction methodology.
- Review of the proposed structural form against the Context for Structures and Other Factors Affecting Choice identified in Sections 4 and 5, respectively, above.
- Comparative capital cost for construction.
- Comparative whole life cost with due regard to maintenance requirements during the working life of the structure.

6.9.3 OPTION 1 – Steel concrete composite multi-girder deck

Description

This comprises:

- Multi span steel concrete composite superstructure with 6 parallel steel beams with integral (or lost) steel crossheads at intermediate support pier positions.

- 3no discrete reinforced concrete columns at each intermediate support pier position and reinforced concrete end abutments, incorporating inspection galleries, assumed to be founded on piled foundations for option comparison.
- Supported on bearings and continuous over intermediate piers. Simply supported at end abutments, fixed at the lower southern end.
- Deck joint details would be a fixed joint at the lower southern end with a movement joint at the higher northern end.

The bridge form requires particular consideration of the stability of the steelwork during erection. If the girders are erected one at a time, temporary propping/support will be required. If there are lifted in pairs, the integral crosshead can be landed directly on the supporting pier with appropriate restraint against sideways rotation being provided.

Compared with other forms of steel/concrete composite superstructure, there is more extensive working required at height in completing the integral crosshead connections which invariably involve large groups of bolts to install to web and flange splices. In addition, the multi-beam solution requires each longitudinal girder to be either curved in plan, or facetted to the curve with bracing provided at changes in direction. For these reasons, this option has been discounted and has not been considered further.

OPTION 2 – Steel concrete composite ladder deck

Ladder decks usually prove to be economical for spans upwards of 35 – 40m, proving especially cost effective on wider and curved decks compared with multiple plate girder type decks.

Option 2 comprises:

- Multi span steel concrete composite superstructure with two longitudinal main girders with the deck slab spanning longitudinally between cross beams spaced at 3-4m centres.
- Discrete circular reinforced concrete columns supporting the two main longitudinal girders and reinforced concrete end abutments, incorporating inspection galleries, currently assumed to be founded on piled foundations for option comparison.
- Supported on bearings and continuous over intermediate support columns. Simply supported at end abutments, fixed at the lower southern end.
- Deck joint details would be a fixed joint at the lower southern end with a movement joint at the higher northern end.

Option 2 is illustrated in Figures 80 and 81 below.

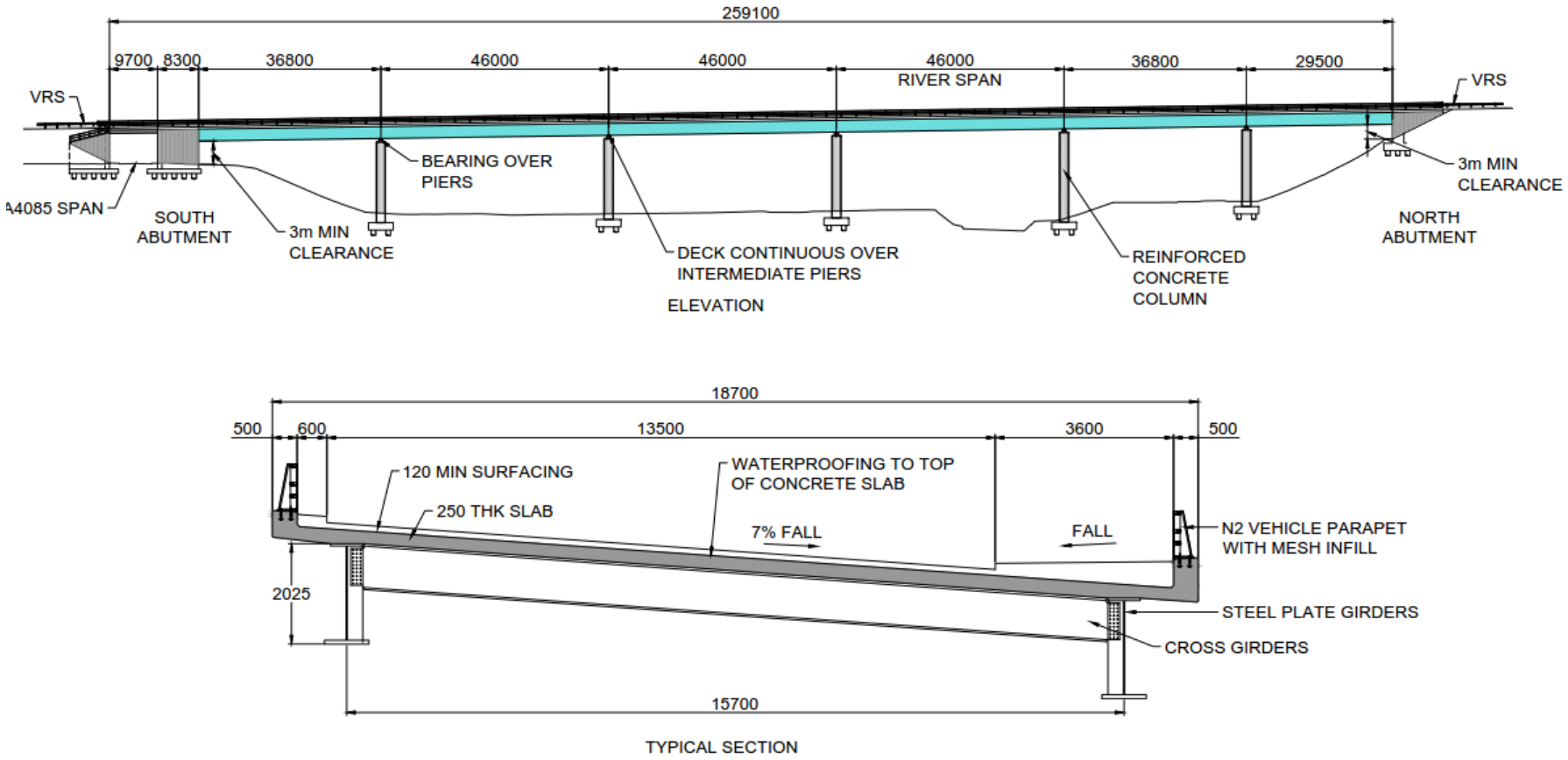


Figure 80. Option 2 Steel/Concrete Composite Ladder Beam deck – Viaduct Elevation, Typical Section

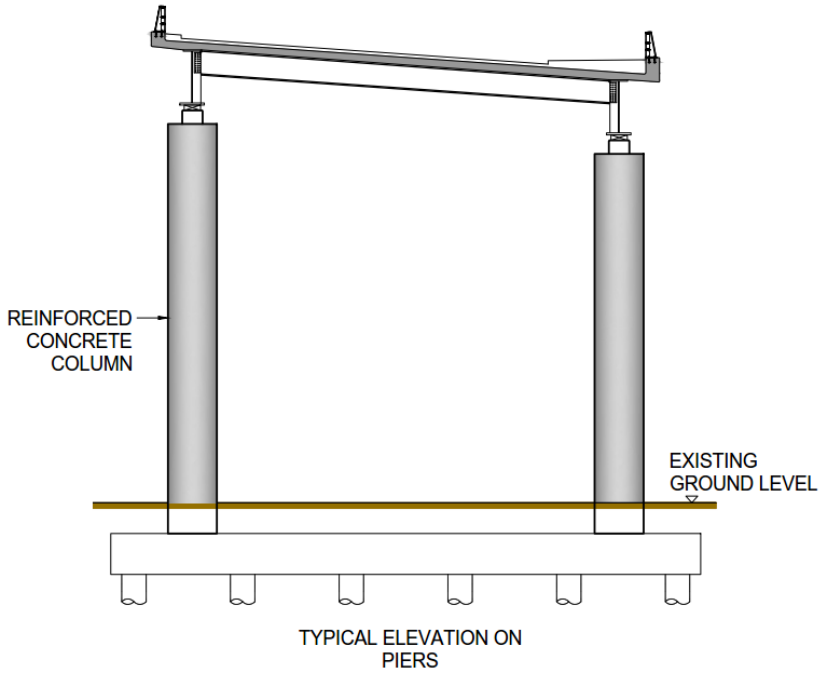


Figure 81 – Option 2 Steel /Concrete Composite Ladder Beam Deck- Pier Elevation

Outline Construction Sequence

The outline construction sequence would be:

- Installation of suitable temporary works for construction of supports either side of Afon Seiont to avoid working in the river channel.
- Construct piled foundations for intermediate piers, abutments and wing walls.
- Construct discrete reinforced concrete columns, abutments and wing walls.
- Erect steelwork from ground level using large capacity cranes.
- Install permanent formwork to form composite deck soffit between cross girder top flanges.
- Fix deck reinforcement and pour in-situ concrete deck, typically span regions first followed by pier regions.
- Backfill abutments and wing walls.
- Complete finishes – waterproofing, parapets, kerbs, surfacing, deck end joints, etc.

Aesthetics and Landscape Effects -Family of structures, Open aspect/aesthetics

The structural form provides a greater construction depth than the multi-beam deck, however, given the height of the viaduct, this is unlikely to impact significantly on the overall appearance. The painted steel beams and the reinforced concrete stringcourse will provide a contrast on the deck elevations which will serve to improve the appearance.

The presence of two main longitudinal girders will lessen the impact of the cross fall on the structure compared with multi beam steel or concrete options which will have very obvious steps in beam levels where seen from the west elevation.

To follow the horizontal curve, it is proposed that the longitudinal girders are curved on plan which affords both construction and aesthetic benefits associated with a constant deck cross section. Note that it is also feasible to construct the viaduct from straight “span girders” and “pier girders” with a change in direction at the main splice positions. However, the edge cantilever will be curved and the combination of this and straight beams will produce an undesirable “scalloped” shaped shadow line on the webs of the girders.

Highway Alignment and Earthworks Balance – Impacts beyond the bridge location

The height of the proposed viaduct above the valley floor means that the form of bridge does not affect flood levels or any other criteria based on vertical clearances, the particular constraint offered by the A4085 being dealt with as described earlier with a structure form having a reduced construction depth.

The steel ladder deck will require provision of at least 3m clearance to the beams’ soffits to deter unauthorised access to the soffit (unless specific deterrent measures are provided), which may involve trimming the earthworks locally in front of the abutments.

Overall Construction Methodology and Approach and Safe by Design

Maintenance of haul route

To permit construction of the viaduct, set down/assembly areas will be established alongside the viaduct location. The haul route will also be maintained alongside the viaduct construction site with a ramp down the valley sides and a Bailey bridge crossing of the Afon Seiont.

Transportable

Fabricated steel beams are relatively lightweight, and can be delivered to site in smaller lengths and spliced on site prior to erection as required.

Previous experience on the A487 Porthmadog Bypass scheme further to the south has indicated that it should be possible to transport braced pairs of beams of length 29m to site. For the spans considered here, individual girder lengths, of 32 metres, are only slightly larger than those proposed at Porthmadog. Preliminary consultation with hauliers has indicated that it should be possible to transport beams of this length to site.

It is anticipated that beams will be delivered to the viaduct construction site along the A4085 from Caernarfon town centre where it crosses the proposed road alignment.

Erectable/Buildability & Programme

The proposed erection arrangement involves lifting using large capacity cranes. This gives the opportunity to assemble completed spans at ground level and lift them as a whole, overcoming issues of stability of the steelwork during erection.

The large cross fall on the deck can be accommodated by stepping the main beams vertically relatively to each other with the cross girders arranged parallel to the cross fall. This allows a constant deck slab thickness and straightforward bolting arrangements, again when compared with multi beam steel or concrete options.

As noted above, to follow the horizontal curve, it is proposed that the girders are curved on plan. The cross girders at close centres are able to easily resist the forces arising from the out of straightness of the main girders without the need for additional bracing as would be required for multi-beam construction.

It is anticipated that the steelwork will be erected from the south abutment working north.

Safe to construct

As noted above, this form of deck allows the opportunity to assemble completed spans at ground level and lift them as a whole by large capacity crane, overcoming issues of stability of the steelwork during erection.

Edge protection can be assembled at ground level prior to erection and once the steelwork has been erected, permanent formwork provides a closed soffit for safe working at height for all subsequent construction operations at height.

Unauthorised access to soffit

There are bearings at the end abutments, and hence enclosures would be required to prevent unauthorised access to the inspection galleries.

It is anticipated that more than 3m headroom clearance will be provided between ground and beam soffit level. This may involve re-grading of the earthworks, particularly at the north abutment, to ensure that this clearance is provided. On this basis, it is not therefore considered necessary to provide deterrent measures to prevent unauthorised access to the bottom flanges.

Durability - Maintenance for future durability

One of the disadvantages of a steel concrete composite superstructure compared with pre-stressed concrete or reinforced concrete alternatives is the need to undertake painting activities through the design life of the bridge. A complete grit-blast and repaint of the structural steelwork will typically be required at approximately 25 year intervals. In addition, a mid-term maintenance intervention will typically be required to address minor breakdown of the protective treatment system and ensure that the 25 year major maintenance cycle is achieved.

This activity will not require any traffic management on the A487. Due to the height of the superstructure above ground level, it is anticipated that access to the superstructure steelwork for the grit-blast and repainting activities will be via a suspended scaffold.

The solution also proposes mechanical bearings above the piers, which would require maintenance painting under the same painting regime as the structural steelwork, and potential replacement at 60 year intervals. The main girders would be provided with additional jacking stiffeners to facilitate this operation, the jacks located on the column tops.

Environment - Noise, local air quality, greenhouse gas emissions, land-take and transport

Of all of the viaduct options, this structural form provides the fewest transport moves and least visual intrusion as a result of larger spans and fewer intermediate supports

Comparative Construction Cost

The comparative cost of the steel/concrete composite option is £5,356,000.

Comparative Whole Life Cost

The comparative whole life cost of steel/concrete composite option is £6,237,000.

6.9.4 OPTION 3 – Steel concrete composite box girder deck

Option 3 comprises:

- Multi span steel concrete composite superstructure with longitudinal box girders.
- Discrete circular reinforced concrete columns supporting the main longitudinal box girders and reinforced concrete end abutments, incorporating inspection galleries, currently assumed to be founded on piled foundations for comparison purposes.
- Supported on bearings and continuous over intermediate support columns. Simply supported at end abutments, fixed at the lower southern end.
- Deck joint details would be a fixed joint at the lower southern end with a movement joint at the higher northern end.

Steel box girders have a number of advantages compared with more traditional I girder elements, being particularly suitable where spans exceed 100m and the flange

sizes of the equivalent plate girders become excessive. They are also of benefit where there is plan curvature, due to their high torsional stiffness and strength, and where there is a desire to reduce the number of support points.

Box girder bridges may also be considered to give a better appearance due to the clean lines of the closed box, and hence may be preferred where aesthetics are important. They can also have improved durability and reduced maintenance of protective coatings due to less exposed surface, fewer edges, avoidance of exposed horizontal surfaces and no exposed bracing and stiffeners.

However for spans less than 100m, box girders are generally less economic than other deck forms. Although a reduction in flange sizes may be possible due to superior load distribution properties, this is more than offset by the amount of internal diaphragms and stiffening and the extra costs in manufacture. Multiple compact boxes for spans up to 50m have been shown to be economic in particular situation where longitudinal stiffeners have been eliminated.

Fabrication costs are high because the assembly and welding accesses are less amenable to automation than with plate girders with greater difficulty of handling and rotating during fabrication and coating.

Whilst erection of closed boxes is easier because they require minimal external bracing to maintain overall stability, open top trapezoidal box girders require temporary bracing during construction to maintain shape and relative twist of the sections until the concrete slab is placed and full torsional rigidity is achieved.

Access must be permitted inside the box girders for welding, protective treatment processes and permanent inspection and hence there are additional risks associated with working in confined spaces compared with I girders.

Based on the above and notwithstanding the benefits that box girder construction can offer, the proposed spans are approximately 50m and accordingly is not deemed to be economic compared with I girders. Accordingly, box girder construction has been discounted and has not been considered further.

6.9.5 OPTION 4 – Pre-cast pre-stressed beam deck

Description

This comprises:

- Multi span precast pre-stressed concrete beam superstructure;
- Reinforced concrete intermediate piers and reinforced concrete end abutments, incorporating inspection galleries, currently assumed to be founded on piled foundations for option comparison.
- Supported on a single line of bearings and continuous over intermediate piers. Simply supported at end abutments, fixed at the southern end.
- Deck joint details would be a fixed joint at the southern end with a movement joint at the northern end.

Options for precast pre-stressed beam decks have required consideration of a different span arrangement to those considered for steel. This is due to the fact that unlike steel beams they cannot be delivered to site in short lengths and spliced on site prior to erection. Preliminary enquiries with a precast beam supplier and a haulier have indicated that it should be possible to deliver 32m long beams site. Thus it is

on the basis of 32m spans that precast pre-stressed beam decks have been considered. Note, however, the lack of flexibility with this arrangement compared with options involving steel beams.

Figure 82 below shows the proposed span configuration.

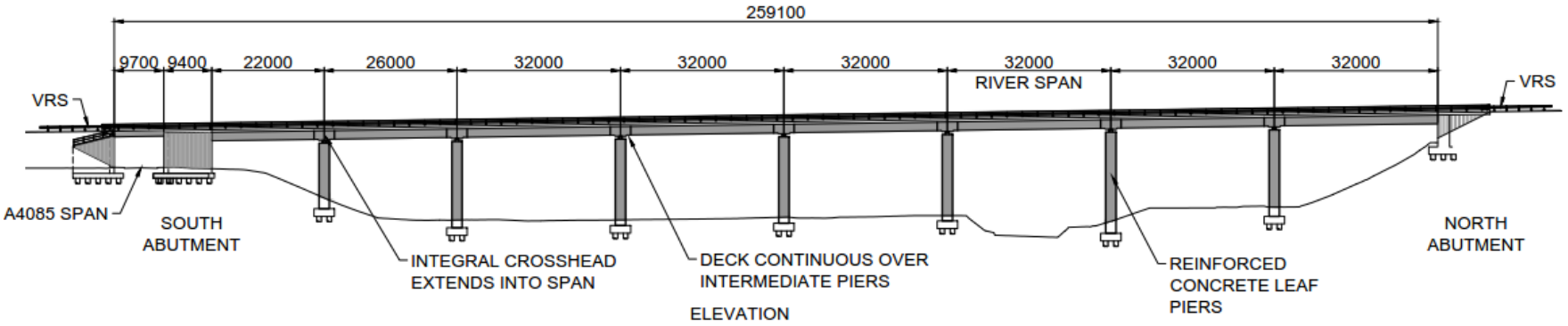


Figure 82. Option 4 Pre-cast Pre-stressed Beam Deck – Viaduct Elevation

For the span of 32m, a number of standard precast pre-stressed beam options are available. Based on these, the following deck cross sections have been considered: Y beams at 1m beam centres; U beams at 2m beam centres, and; W beams at 3m centres.

These are illustrated in the Figures 83 to 85 below.

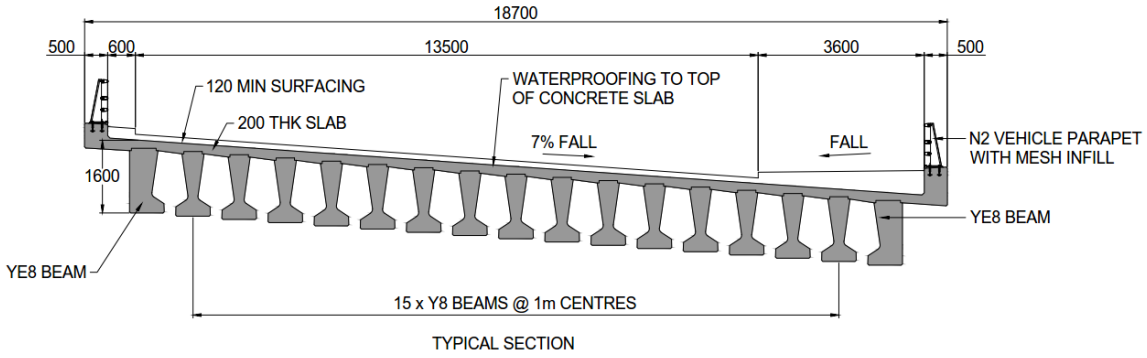


Figure 83. Option 4 Pre-cast Pre-stressed Concrete Beam deck – Y-Beam Deck Section

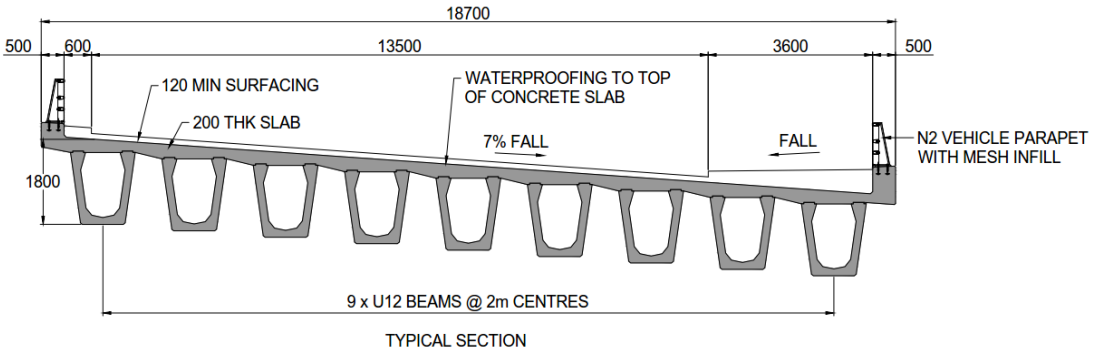


Figure 84. Option 4 Pre-cast Pre-stressed Concrete Beam deck – Y-Beam Deck Section

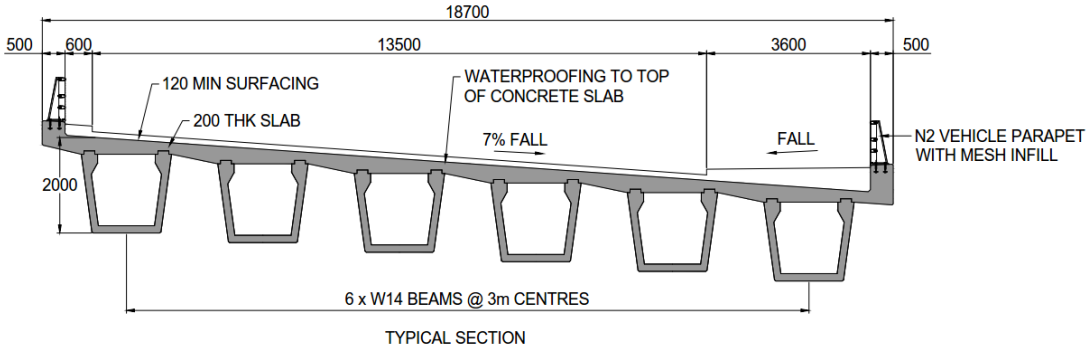


Figure 85. Option 4 Pre-cast Pre-stressed Concrete Beam deck – W-Beam Deck Section

There is the advantage of the W beam deck over the U beam deck and the U beam deck over the Y beam deck in requiring fewer beams for transportation and erection, but this comes at the disadvantage of increased construction depth and lift weights.

As has been described for the Afon Gwyrfai Viaduct, the formation of longitudinal continuity at intermediate supports is significant for continuous bridges constructed using precast pre-stressed beams. A number of options are available and have been employed. The options differ in the way that the precast beams are supported prior to making them continuous.

In general, these options can be considered to fall into 2 main categories:

- Wide pier with precast beams temporarily supported on a widened pier;
- Narrow pier with precast beams temporarily supported on temporary propping off the pier foundations.

Options involving “tied slabs” and “continuously separated slabs” have not been considered as there is the risk that of deterioration to inaccessible faces.

These options are illustrated in Figures 86 and 87 below.

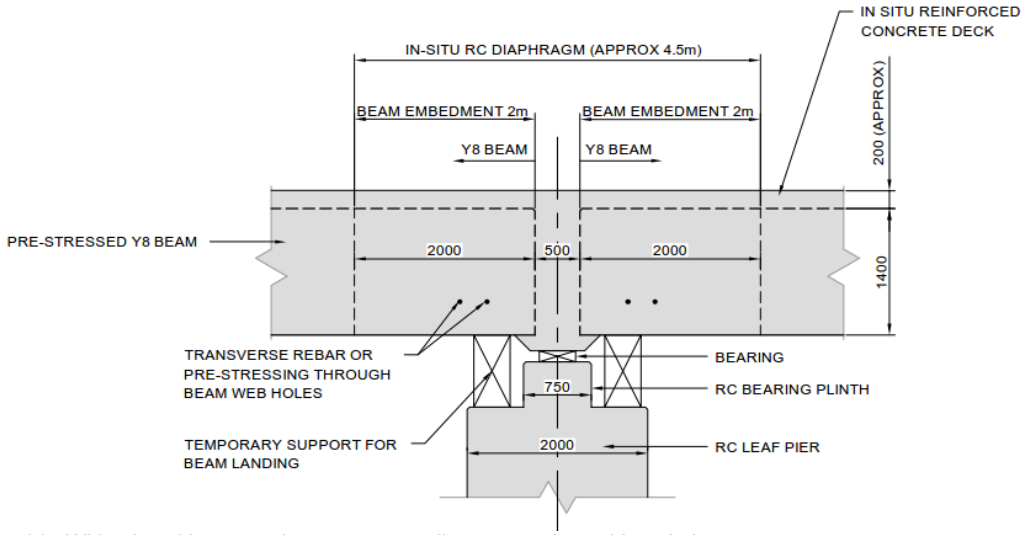


Figure 86. Wide pier with precast beams temporarily supported on widened pier.

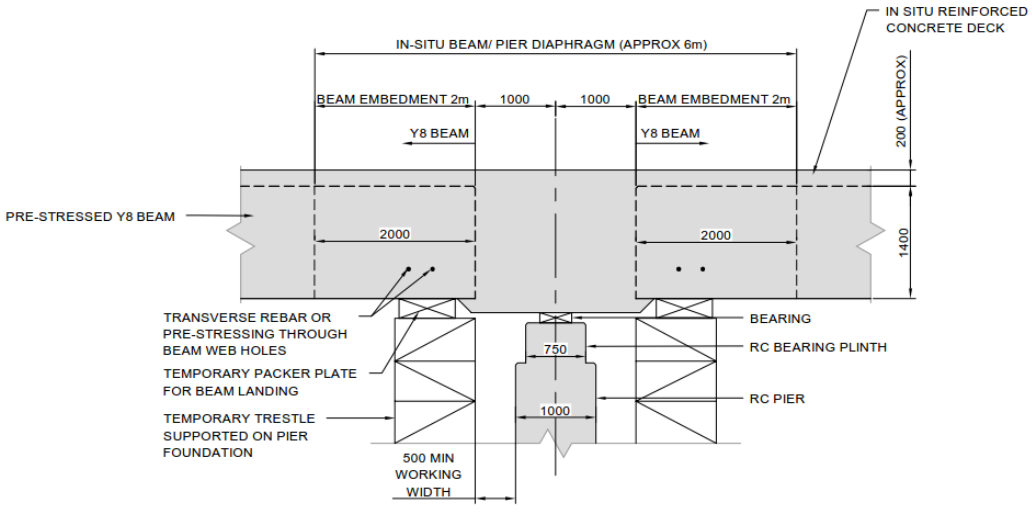


Figure 87. Narrow pier with precast beams temporarily supported on temporary propping.

The principal advantage of the wide pier option is that temporary props are not required since the permanent bearing shelf is of sufficient width.

- A variety of substructure options are available based on the options for providing longitudinal continuity:
- Pair of Y-shaped piers with bearings provided for each line of beams;
- Single Y-shaped pier with bearings provided for each line of beams;
- Discrete columns with integral transverse spanning crosshead and reduced number of bearings.

These options are illustrated in Figures 88 and 90 below.

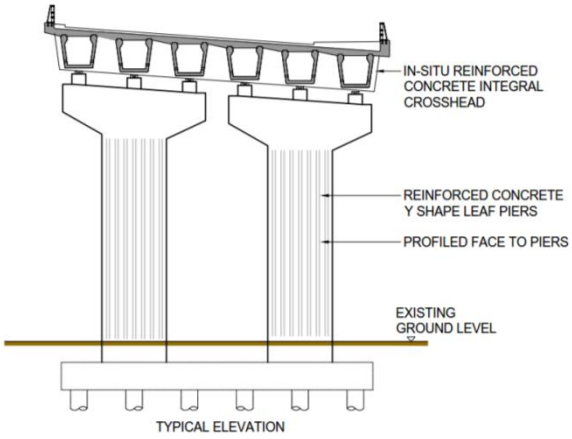


Figure 88. Option 4 Pre-cast Pre-stressed Concrete Beam deck – Pair of Y-Shaped Leaf Pier Solution

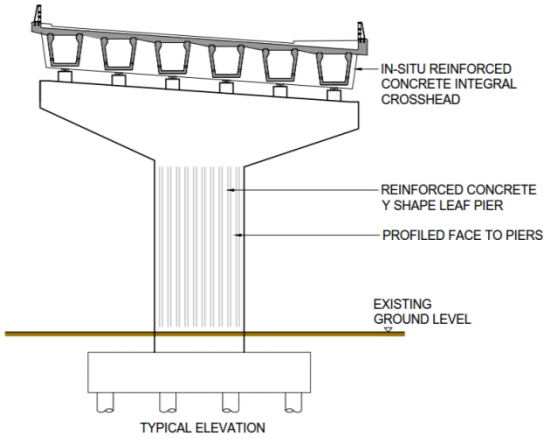


Figure 89. Option 4 Pre-cast Pre-stressed Concrete Beam deck – Single Y-Shaped Leaf Pier Solution

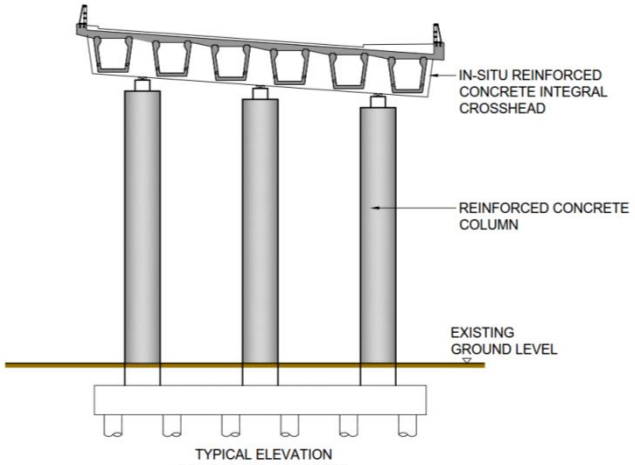


Figure 90. Option 4 Pre-cast Pre-stressed Concrete Beam deck – Discrete Column Solution

The first 2 options align with the preferred approach of temporarily supporting the beams on the permanent pier, whereas the 3rd option requires significant temporary props – given the height of the viaduct across the Afon Seiont, this is considered undesirable due to the significant amount of work required at height compared with other options.

Outline Construction Sequence

The outline construction sequence would be:

- Installation of suitable temporary works for construction of supports either side of Afon Seiont to avoid working in the river channel.
- Construct piled foundations for intermediate Y shaped piers, abutments and wing walls. Note that an additional number/larger diameter piles are expected compared with the equivalent steel solution owing to the heavier superstructure.
- Construct reinforced concrete Y piers, abutments and wing walls.
- Install permanent bearings above piers and abutments.
- Deliver precast pre-stressed beams to site and lift individually onto individual temporary bearings located on the bearing shelves. Edge precast beam to have edge protection attached at ground level prior to lifting. Beams braced together for stability on temporary bearings.
- Erect soffit formwork and formwork between beams for construction of integral crosshead/diaphragm over intermediate supports and diaphragm at end supports. Erect permanent formwork to form deck soffit between beam top flanges.
- Fix reinforcement for crossheads/diaphragms and fix deck reinforcement.
- Pour in-situ concrete crossheads/diaphragms as first stage and deck slab as a second stage of construction of a continuous and composite structure.
- Strip formwork to soffit of integral crosshead/diaphragms over intermediate supports.
- Release structure from temporary bearings onto permanent bearings.
- Backfill abutments and wing walls.
- Complete finishes – waterproofing, parapets, kerbs, surfacing, deck end joints, etc.

Aesthetics and Landscape Effects -Family of structures, Open aspect/aesthetics

The structural form provides a similar construction depth compared with the steel/concrete composite option, however, the shorter spans and increased number of intermediate Y-shaped pier supports will give present a significantly inferior visual impact that the steel alternative.

The horizontal curve and super-elevation will also mean that the beams will need to be “facetted” to accommodate the curve and stepped relative to each other vertically across the width of the structure, detracting further from the appearance of the option.

The combination of a curved edge cantilever and straight beams will produce a “scalloped” shaped shadow line on the beam webs to the outer elevations.

Highway Alignment and Earthworks Balance – Impacts beyond the bridge location

The height of the viaduct above the valley floor means that the different forms of construction being considered are not likely to impact beyond the bridge location appreciably.

The absence of handholds and ledges on precast pre-stressed beams will mean that there is no particular requirement to require at least 3m clearance to the soffit.

Overall Construction Methodology and Approach and Safe by Design

Maintenance of haul route

To permit construction of the viaduct, set down/assembly areas will be established alongside the viaduct location. The haul route will also be maintained alongside the viaduct construction site with a ramp down the valley sides and a bailey bridge crossing of the Afon Seiont.

Transportable

Precast pre-stressed beams weigh significantly more than fabricated steel beams (48 tonnes for Y8 beams, 61 tonnes for U12 beams and 80 tonnes for W14 beams), and unlike steel beams cannot be delivered to site in short lengths and spliced on site prior to erection.

Preliminary enquiries with a precast beam supplier and a haulier have indicated that it should be possible to transport precast beams of 32m length to site. Removal of some street furniture, e.g. traffic signs and lamp posts, may be required to negotiate part of the route from the A55 at Bangor to the viaduct site.

It is anticipated that beams will be delivered to the viaduct directly from the A4085 where it crosses the proposed alignment.

Erectable/Buildability & Programme

The bridge is significantly more complex to design and construct than the equivalent steel structure owing to the need to provide continuity between the ends of the precast pre-stressed beams over the intermediate pier supports.

With the integral crosshead/diaphragm having to accommodate longitudinal as well as transverse load effects, reinforcement can become congested and difficult to detail and therefore difficult to fix on site. Projecting bars or strand from the ends of the precast beams, provided to resist longitudinal sagging moments as a result of creep and shrinkage, further complicate reinforcement fixing.

There are more stages in the construction of the longitudinal continuity compared with steel, with the need for the beams to be supported on temporary bearings and additional stages of reinforcement fixing and placing concrete to integral diaphragms and deck slabs. Much of this work would also be carried out at height from scaffolding placed around the pier tops.

The large cross fall and provision of stepped longitudinal main beams means that whilst a constant thickness deck slab would be assumed for the purpose of design resistance, the thickness of deck slab will vary. This is due to the difference in slope of the top surface of the slab and the slope of the permanent formwork on the soffit spanning between the rebates along the top edges of the beams. Hence, the slab design will be less efficient that the ladder beam deck which has a constant deck thickness.

As result of the above complexity, it is anticipated that construction of the viaduct would be much less rapid than the steel viaduct.

It is anticipated that the precast beams will be erected from the south abutment working north.

Safe to construct

The lifting of edge beams with cantilever formwork in place to provide edge protection is typically inherently unstable during erection. Precast concrete stringcourses could be utilised in lieu of an in-situ stringcourse to mitigate such instability during erection. However, temporary works are typically required between all beams to stabilise them against over-turning during construction.

Permanent formwork provides a closed soffit for safe working at height for all subsequent construction operations at height.

The provision of continuity between longitudinal beams also requires for greater amount of working at height from scaffolding placed around the pier heads than the equivalent steel option.

Unauthorised access to soffit

There are bearings at the end abutments, and hence enclosures would be required to prevent unauthorised access to the inspection galleries.

Precast pre-stressed beams do not provide ledges and handholds to the extent of steel and notwithstanding the construction depth being greater than for steel and hence the clearance between ground and beam soffit level being reduced, unauthorised access to the soffit of the viaduct is not considered to require any deterrent measures.

<u>Durability - Maintenance for future durability</u>

With no structural steelwork to paint, a precast pre-stressed beam superstructure provides a significant advantage compared with the steel/concrete composite alternative in terms of future maintenance liability.

Precast pre-stressed beams are manufactured in a factory under controlled conditions to a consistently high quality such that maintenance in the form of concrete repairs in the future is unlikely.

The use of permanent formwork to the deck soffit also means that these surfaces will be protected from environment degradation.

Notwithstanding the reduced maintenance requirements of the concrete superstructure, this solution does however propose mechanical bearings above the piers, which would require a maintenance intervention in their own right for painting and potential replacement at 60 year intervals. A mid-term maintenance intervention will typically be required to address minor breakdown of the protective treatment system to ensure that the 25 year major maintenance cycle is achieved.

Environment - Noise, local air quality, greenhouse gas emissions, land-take and transport

Compared with the steel/concrete composite option, this structural form requires a greater number of transport moves, particularly for the Y beam deck. These could potentially be more disruptive to the existing road network should temporary closures or diversions be required in order to accommodate deliveries. The delivery of such beams is also more disruptive to the local environment and communities in that the longer lengths of beams to be delivered means that street furniture would potentially require removal temporarily along the route to site.

Whilst the use of fewer, larger beams (U and W sections) would reduce the numbers of beams to be delivered, the significant increase in beam weight would require larger vehicles with more axles along the existing road network.

Comparative Construction Cost

The comparative cost of the precast pre-stressed beam deck option is £7,222,000.

Comparative Whole Life Cost

The comparative whole life cost of the precast pre-stressed beam deck option is £7,275,000.

6.9.6 OPTION 5 - Post-tensioned concrete deck

Description

This comprises:

- 3 span post-tensioned concrete box girder superstructure;
- Discrete reinforced concrete columns and reinforced concrete end abutments, incorporating inspection galleries, currently assumed to be founded on piled foundations.
- Supported on bearings and continuous over intermediate piers. Simply supported at end abutments, fixed at the southern end.
- Deck joint details would be a fixed joint at the southern end with a movement joint at the northern end.

Post-tensioned concrete box girders can be used for a wide variety of spans from 40m up to 300m. They can be either of in situ concrete or precast concrete segmental construction.

In situ concrete construction has the particular advantages of efficient use of concrete and pre-stress and the flexibility of in span arrangements, although it has the disadvantage of labour intensive activities on site and long construction times for larger structures. They can be used for spans of up to 300m when haunched.

For spans of up to 60m, it is common for concrete to be cast in sections span by span supported by falsework from the ground or with a truss spanning between the piers.

Above spans of 60m, it is common to use a haunched section cast within a travelling form as a balanced cantilever about a pier.

Where the bridge alignment is straight or on a constant radius curve, launched single cell box girders may be used to overcome access problems or to avoid obstructions at ground level. Commonly used for spans of up to 60m, the technique has been used for longer spans of up to 100m with help of temporary piers placed to reduce the effective span during launching. Launching, however, creates further complexities of design and construction during generation of many intermediate stages.

Precast concrete segmental box girders are found to be very economical for long bridge lengths due to the savings associated with maximising repetition in factory conditions. They allow rapid construction with minimum on site work. They do have disadvantages including the costs of setting up the casting yard and the special erection equipment needed. Span lengths vary typically up to 150m above which the segment weight becomes excessive.

The most common method of erecting segments is by the balanced cantilever technique, either with a gantry, or a crane or a special lifting frame fixed to the deck.

For both forms of construction, for spans above 60 or 70m, it is common to use a haunched section.

For the Pont Afon Seiont Newydd, the following arrangement has been given brief consideration:

- Pair of single box girders with longitudinal in situ stitch;
- 3-span continuous with main span of 72m.

This is illustrated in the Figure 91 below.

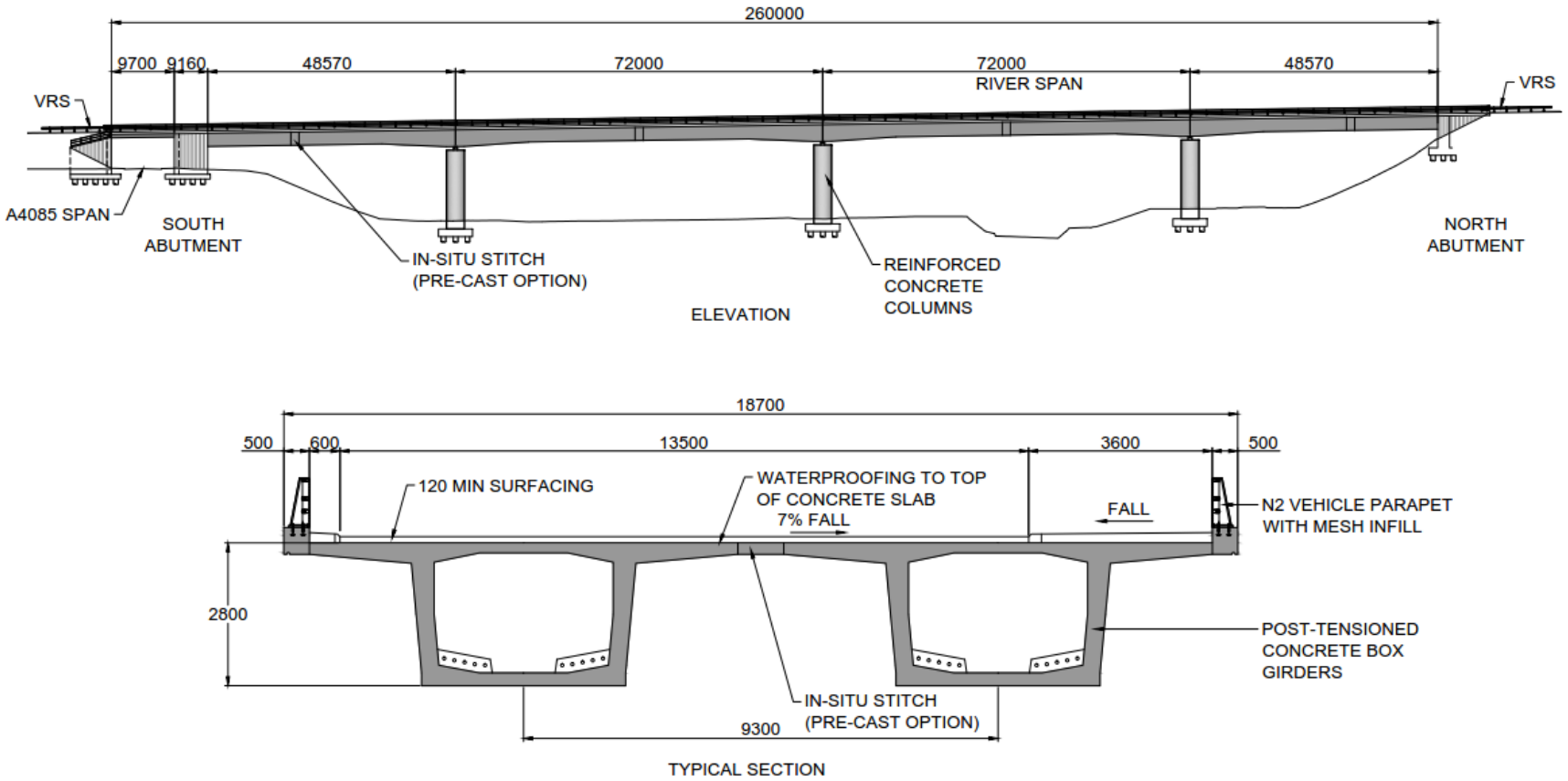


Figure 91. Option 5 Post-Tensioned Concrete deck – Viaduct Elevation, Typical Section

For the Pont Afon Seiont Newydd, post-tensioned concrete box girder construction allows the adoption of a span configuration which avoids intermediate piers within the north slope of the valley.

However, the length of the viaduct means that precast segmental construction is unlikely to be economic, as described above. For in situ construction, there are complexities associated with both casting from falsework and launching. Using falsework requires supports within the north slope that it is the very intention to avoid using this form of structure. Launching for what is a relatively short structure for this form is not considered economic.

The relatively poor economics of this form of bridge has been borne out following research into unit area costs. This has shown that an all in cost of approximately £3k per square metre of deck is not uncommon. Based on the proposed deck area, this gives a budget cost of £13,000,000, which is significantly greater than for other structure forms.

For this reason, post-tensioned concrete box girder deck has been discounted and has not been considered further.

6.9.7 Summary of Comparative Capital Works Costs for Confirming Design Viaduct Options

A summary of the comparative capital works costs for the viaduct options based the conforming design is presented in the table below.

	Superstructure Materials				
Span arrangement	**Steel concrete composite multi-beam deck**	**Steel concrete composite ladder deck**	**Steel concrete composite box girder deck**	**Pre-cast pre-stressed concrete beam deck**	**Post-tensioned concrete deck**
0	**Option 1**	**Option 2**	**Option 3**	**Option 4**	**Option 5**
Capital Cost	N/A	£5,356,000	N/A	£7,222,000	£13,000,000

6.9.8 Summary of Comparative Whole Life Costs for Conforming Design Viaduct Options

A summary of the comparative whole life costs for viaduct options based on the conforming design is present in the table below.

	Superstructure Materials				
Span arrangement	**Steel concrete composite multi-beam deck**	**Steel concrete composite ladder deck**	**Steel concrete composite box girder deck**	**Pre-cast pre-stressed concrete beam deck**	**Post-tensioned concrete deck**
0	**Option 1**	**Option 2**	**Option 3**	**Option 4**	**Option 5**
Whole Life Cost	N/A	£6,237,000	N/A	£7,275,000	N/A

6.9.9 Recommendations for Conforming Design Viaduct Solution

Based on the summary of comparative capital and whole life costs:

- Option 2, a steel concrete composite ladder beam deck, provides the lowest capital works cost solution.
- Option 2, a steel concrete composite ladder beam deck, provides the lowest whole life cost solution.

In addition, Option 2 has significant construction advantages over Option 4.

On the basis of the provision of a minimum comparative capital works and whole life cost structure, and on the basis of the review of the proposed structural forms against the Context for Structures and Other Factors Affecting Choice identified in Sections 4 and 5 of this report, respectively, it is recommended that Option 2, a six span steel concrete composite ladder beam deck be adopted for Structure S112 Pont Afon Seiont Newydd (WG Asset Number A487 621).

It is recommended that the crossing of the A4085 at the southern end of the viaduct be achieved via the provision of a pre-cast, pre-stressed concrete beam deck supported on integral reinforced concrete abutments.

6.9.10 REFINEMENT OF OPTION 2 CONFORMING DESIGN PREFERRED OPTION

Receipt of detailed topographical survey during Key Stage 3

Based on the outcome of the comparison exercise above, Option 2 for the Conforming Design has been reviewed and finessed against the various constraints for which further information has been determined as Key Stage 3 has progressed.

As noted above, detailed topographical survey, ground investigations and flood modelling has been progressing alongside preparation of this Design Options Report, and indeed, at time of writing, only the detailed topographical survey has been received.

However, the receipt of this topographical survey has provided significantly more detail than had been available at Key Stage 2, particularly in the vicinity of the river and the north slope of the valley, which has allowed the position of the north abutment to be reviewed.

The position of the north abutment is illustrated in Figure 92 below.



Figure 92. Position of proposed north abutment location relative to north slope following topographical survey

The implication of this is that at the abutment, considering the bridge to be square (preferable for design, detailing and construction), the exposed height of abutment would be 4m more at the north east corner than at the north west corner.

Hence, for the preferred ladder deck option, with the north abutment positioned in the optimum position to provide a minimum of 3m soffit clearance at the north west corner of the abutment would involve providing 7m soffit clearance at the north east corner with the ground profile along the front face of the abutment inclined at an angle between these two level.

This would be undesirable from a visual impact point of view with the height of the abutment at the north west corner and the north west wing wall being significant - this is illustrated in Figure 93 below.



Figure 93. Visualisation showing height of abutment and extent of wing walls at north east corner

The above may be mitigated by providing a level surface 3m below the girder soffit level at the north east corner and extending this level surface across the front face of the abutment to the north west corner. At the north west corner, the existing slope would need to be excavated and re-profiled accordingly.

This is illustrated in Figure 94 below.

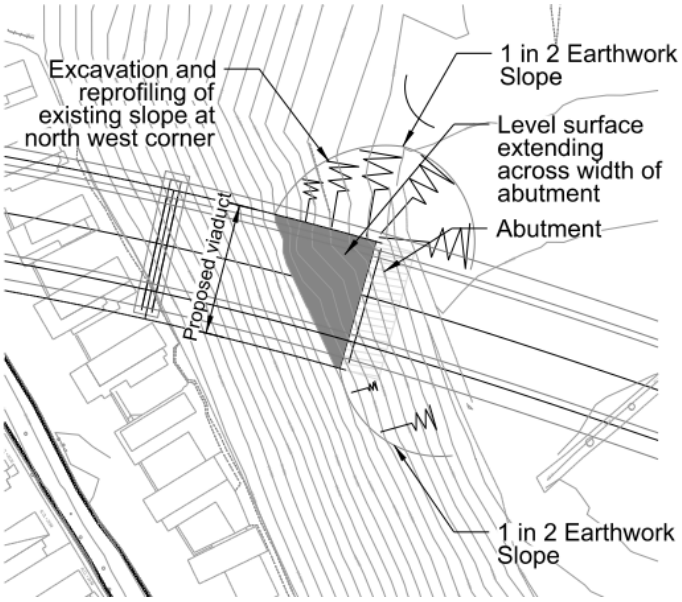


Figure 94. Proposed benching of slope and scalloping of north west slope

The above exercise was found not to affect significantly the position of the north abutment assumed during the early stages of Key Stage 3 for purposes of consideration of options.

Addressing the risk of GI

Whilst the receipt of topographical survey has identified the above issue with the orientation of the slope, the risk of ground conditions remains.

Due to land access issues, there is the risk that ground investigation works may not be completed until the start of Key Stage 6, hence assumptions on the ground conditions have been made based on limited information.

The geology of the north slope has considered a depth of weak surface deposits overlying more competent mudstone strata. Initial indications from exploratory holes suggest a 5m depth of these weak surface deposits at the top of the north slope with an 8m depth on the valley floor. This has allowed the profile of the more competent mudstone strata to be inferred and hence has allowed the position of the north abutment to be reviewed.

In this review, it is assumed that the north abutment would be piled due to the uncertainty of the ground conditions, although it is acknowledged that the effect of the slope would reduce their effectiveness to lateral loads from earth pressure.

It is also worth noting that the deeper the abutment is founded within the slope, larger the horizontal loads applied to the piles since horizontal earth loads are proportional to the square of the retained height.

Taking into account the proposed construction depth of the ladder deck option, the 3m clearance to the soffit, an assumed depth below ground level for the pile cap and a thickness of the pile cap, the founding level of the abutment can be determined and hence its position relative to the mudstone strata.

This is illustrated in Figure 95 below.

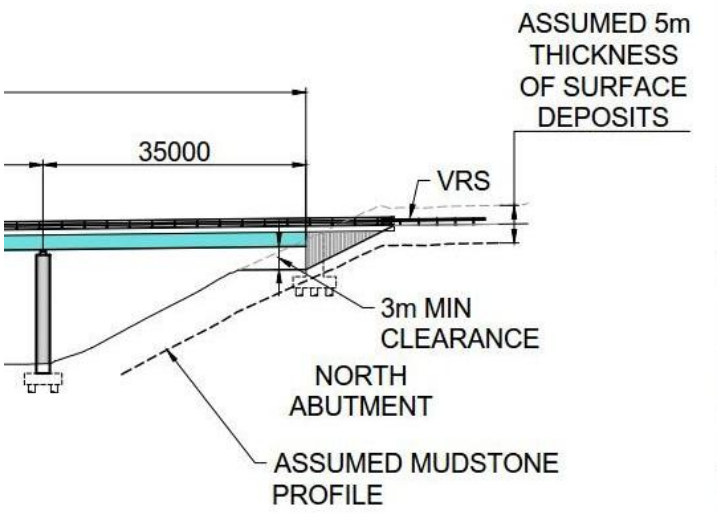


Figure 95. Proposed location of north abutment based on inferred ground conditions

The preferred solution for the Conforming Design, Option 2, has been revisited to assess the implications of the proposed alteration to the north abutment position as follows:

- Broadly in line with the conforming design with the first intermediate pier within the north abutment slope;
- Refinement of options considered previously avoiding the first intermediate pier within the north abutment slope.
- Modification of the north slope through use of natural and reinforced soil slopes.

Each of the above is considered in turn, adopting the option numbering 2A, 2B and 2C respectively to represent the development of Option 2, the preferred solution for the Conforming Design.

6.9.10.2 OPTION 2A – Modified north abutment, pier within slope

This option is broadly in line with the conforming design described earlier, in that it springs from an abutment atop the north slope and has a pier within the slope with appropriate temporary works.

Figure 96 illustrates this arrangement.

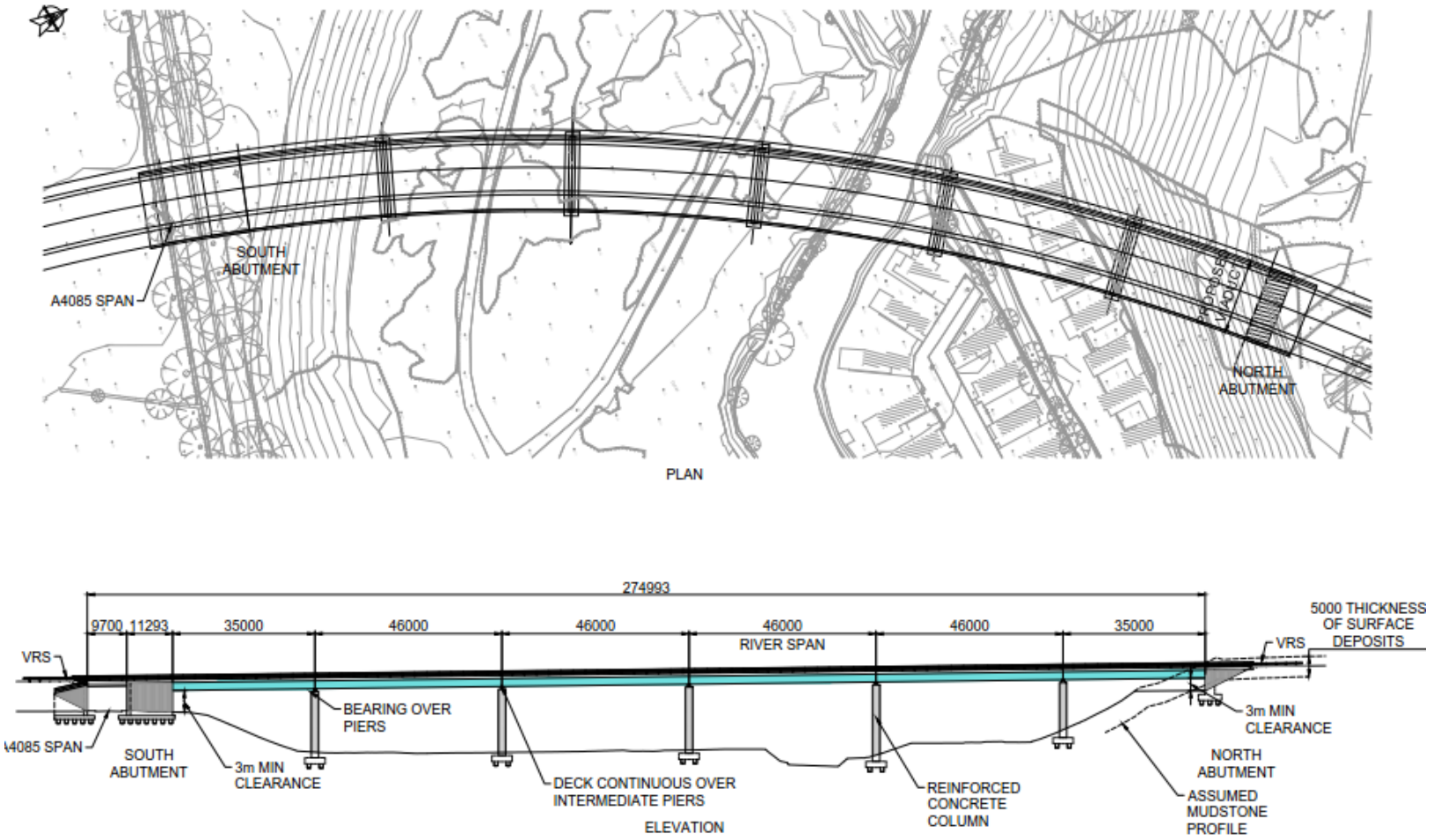


Figure 96. Option 2A Modified North Abutment, Pier Within Slope – Viaduct Plan and Elevation

Based on the 46m main span arrangement which has been considered to date for the preferred option, the span configuration has been amended to accommodate the modified position of the north abutment and avoid siting intermediate piers within/in proximity to the Afon Seiont.

This does, however, lead to a pier being located within the north slope which is considered sub-optimal requiring provision of a temporary works solution, and a subsequent permanent works reinstatement solution.

It should be acknowledged however that the north abutment and pier positions are based on very limited ground information, and that they will be reviewed following receipt of detailed ground investigation information and associated laboratory testing.

6.9.10.3 OPTION 2B – Modified north abutment, pier outside slope

This option spans the north slope avoiding having a pier within the slope. Again, this option would entail having a span that springs from an abutment atop the slope, but with a pier planted in the railway embankment at the bottom. This option requires a back span in the order of 55m, and an associated increase in main span to approximately 70m to then cross the river to avoid siting piers within the river.

Figure 97 shows this arrangement in plan and elevation.

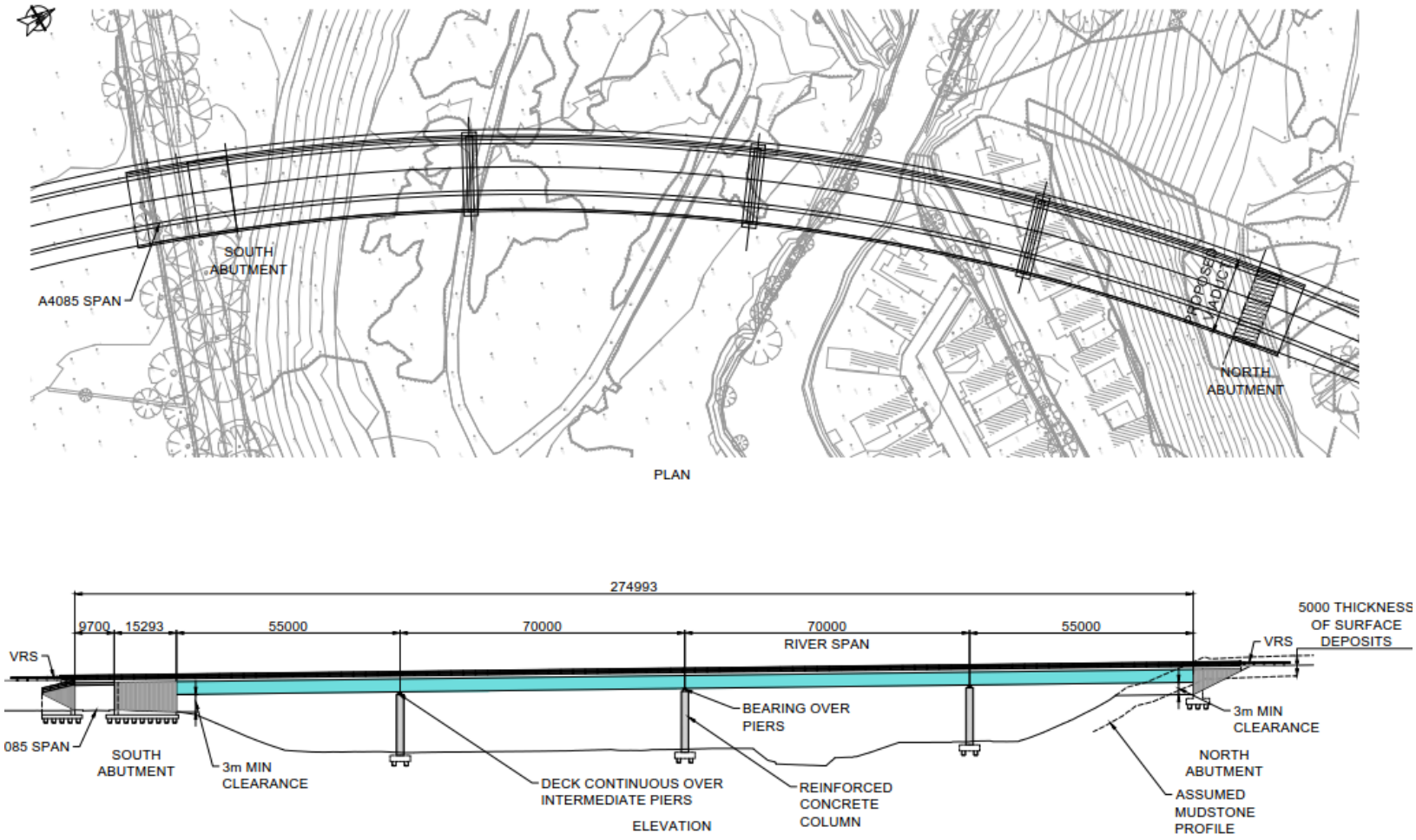


Figure 97. Option 2B Modified North Abutment, Pier Outside Slope – Viaduct Plan and Elevation

Spans of this length lend themselves to consideration of a heavy ladder deck or steel or concrete box girder superstructures. However, as noted earlier such large spans would present significant delivery and construction challenges and hence for the reasons stated earlier, i.e. cost and constructability, this option is discounted.

6.9.10.4 OPTION 2C – Reinforced soil north slope

This option involves modifying the earthworks slope to the north end of the viaduct utilising a mixture of steep reinforced soil slopes and naturally stable slopes. This could allow a reduced viaduct length incorporating the 46m main span arrangement which has been considered to date for the preferred option.

Figure 98 illustrates this arrangement.

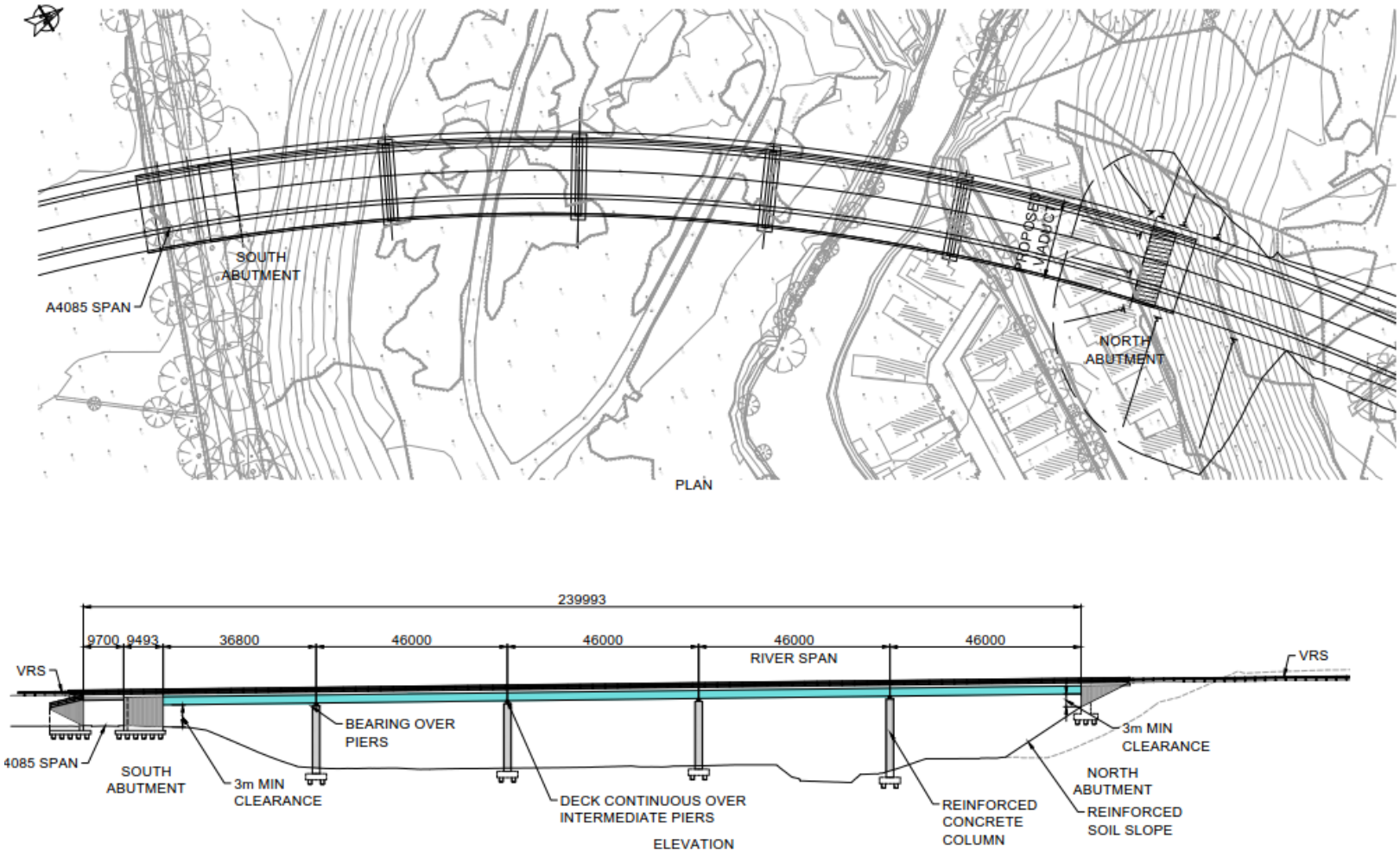


Figure 98. Option 2C Reinforced Soil North Slope – Viaduct Plan and Elevation

The adoption of this option would help to de-risk the Key Stage 3 with regard to ground investigation, as 2 No. boreholes could be undertaken in the proposed area of the reinforced slope without impacting directly upon the caravans, although it does not remove the need for further boreholes at a later date.

It is also beneficial in terms of landscape effects, as it would allow more effective mitigation through screen planting on the embankment, thereby reducing the impact on the visual context. There could also be benefits from a noise perspective where the embankment would allow noise mitigation in a more sensitive manner.

This option does however raise concerns from an ecological perspective, since the proposed embankment is on the northern side of the valley, as follows:

- Increases the habitat loss including broadleaf woodland and scrub which in itself is an increased ecological impact and would in turn increase the indirect impacts on any and all species that utilise these habitats and those adjacent.
- Implications for maintaining bat commuting routes across the scheme and overall bat connectivity in the wider landscape which has been raised by NRW as a key issue. NRW has also stated that they wish to see overall improvement and enhancement to landscape connectivity for bats which this would undermine.
- Increases the potential disturbance to otters and water voles along the river as well as the impacts from terrestrial habitat loss, a particular concern for otters in particular as this species has been recorded utilising terrestrial habitats in this area at a greater frequency than elsewhere in Wales. The loss of and disturbance to woodland and scrub habitats also has the potential to impact dormice populations if found to be present.

It should also be noted that a potential badger sett has been identified in this area and if confirmed, or others should be found, this would further increase the ecological impact of this option, the risk of which is greater due to the larger development footprint and habitat clearance that would be required.

The above ecological disbenefits of this option are considered sufficient to outweigh the benefits and as a result this option has been discounted.

6.9.11 Summary of Refinement of Option 2 Conforming Design Preferred Option

On the basis of the above, Option 2A, which is broadly in line with the previous preferred solution for the conforming design, is recommended.

The location of a pier located within the north slope, based on very limited ground information, is considered sub-optimal and will be reviewed when detailed ground investigation information and associated laboratory testing becomes available.

It is anticipated that the on-going risk of lack of ground investigation will be managed through the choice of the foundations to be presented at Approval in Principle stage, which will be reviewed and amended/added to, if necessary, when the ground investigation does become available possibly early in Key Stage 6. However, with the proposed pile solution, this may be accommodated, for example, by changing diameter of the piles rather than the overall configuration of the structure.

The General Arrangement for the structure, based on the recommended Option 2A, is contained in Appendix D.

6.9.12 Option 6 – Embankment at Southern End

At the TWG Structures meeting of 11th May 2015, it was agreed that a further option would be considered as part of a Value Engineering exercise.

This option involves extending the embankment into the flood plain on the south side of the river.

Since it represents a change from the Conforming Design on which options have been considered to date, it has been titled Option 6.

At time of writing, this exercise is on-going and is to be reported separately from this Structures Design Options Report.

6.10 Ancillary Structures and Strengthened Slopes

6.10.1 Drainage headwalls at inlets and outfalls to drainage ponds, if required, will be less than 1.5m retained height, and do not therefore fall within the scope of structures requiring Technical Approval in accordance with *BD2/12 Technical Approval of Highway Structures*. Options and details for such minor structures will therefore be developed at Key Stage 6 Detailed Design.

6.10.2 No proposed retaining walls have been identified for the scheme.

6.10.3 No strengthened earthworks slopes above 45 degrees have been identified for the scheme.

6.10.4 No environmental barriers above 3m height and hence requiring Technical Approval above Category 0 in accordance with *BD2/12 Technical Approval of Highway Structures* have been identified for the scheme to date.

6.10.5 No river training works in the form of vertical retaining walls of more than 1.5m retained height have been identified for the scheme.

6.10.6 There will be a number of large ADS signs of height greater than 7m to the top of the foundation for which technical approval will be required in accordance with *BD2/12 Technical Approval of Highway Structures*. Foundation and post options will be determined at detailed design, but are likely to comprise proprietary posts with conventional spread foundations.

7 SUMMARY AND RECOMMENDATIONS

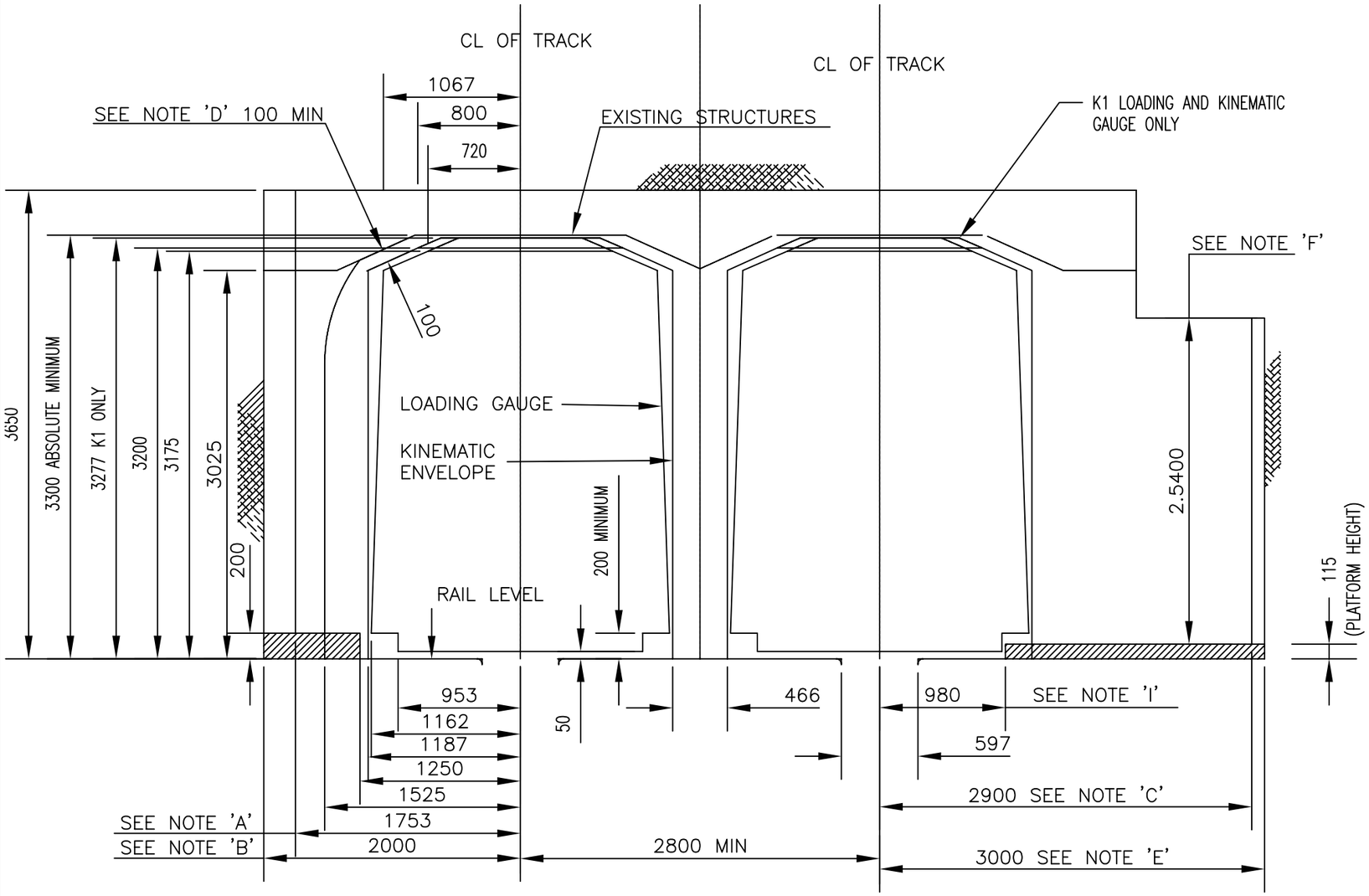
7.1.1 The table below contains a summary of the structures to be provided as part of the scheme, and contains recommendations as to the form and materials to be developed through the next stages.

Structure	WG Structure Name	WG Asset No.	Type	Recommended Structural Form and Materials
S101	Ty Hên Culvert	A487 550 C68	1.8m Pipe	1.8m diameter proprietary concrete pipe.
S101A	Pont Parc Underpass	A487 561	Box Underbridge	In-situ reinforced concrete box structure with either in-situ reinforced concrete roof slab or a roof slab incorporating pre-cast concrete beams. 7.2m wide x 5.8m high nominal internal opening.
S102	Afon Rhyd Culvert	A487 565	Box Culvert	In-situ or proprietary pre-cast reinforced concrete box culvert. 3.2m wide x 1.8m high nominal internal opening.
S103	Ty'n Llan Overbridge	A487 571	Overbridge	3 span pre-cast pre-stressed concrete beam superstructure made fully integral with 2 no. reinforced concrete piers and 2 no. bankseat abutments.
S104	Geufron Culvert	A487 571 C80	1.8m Pipe	1.8m diameter proprietary concrete pipe.
S105	Dinas Accommodation Underpass	A487 575	Box Underbridge	In-situ reinforced concrete box structure with either in-situ reinforced concrete roof slab or a roof slab incorporating pre-cast concrete beams. 4.5m wide x 4.65m high nominal internal opening.
S106	Afon Gwyrfai Viaduct	A487 581	Viaduct	8 span steel concrete composite multi-beam superstructure continuous over reinforced concrete leaf piers, with reinforced concrete cantilever abutments.
S107	Pont Llydiart Gwyn	A487 585	Box Underbridge	In-situ reinforced concrete box structure with either in-situ reinforced concrete roof slab or a roof slab incorporating pre-cast concrete beams. 7.2m wide x 5.8m high nominal internal opening.
S108	Pont Cefnwerthyd	A487 591	Underbridge	Single span pre-cast pre-stressed concrete solid beam infill superstructure cast fully integral with deck end bankseats, supported on reinforced soil substructures incorporating vertical pre-cast concrete fascia panels.
S109	Pont Ceriw NMU Overbridge	A487 601	Overbridge	Single span pre-cast pre-stressed concrete beam solid infill superstructure cast fully integral with deck end bankseats, supported on reinforced soil substructures incorporating vertical

Structure	WG Structure Name	WG Asset No.	Type	Recommended Structural Form and Materials
				pre-cast concrete fascia panels.
S109A	Pen Y Bryn Culvert 3	A487 601 C01	1.8m Pipe	1.8m diameter proprietary concrete pipe.
S110A	Pen Y Bryn Culvert 2	A487601 C58	1.8m Pipe	1.8m diameter proprietary concrete pipe.
S110	Pen y Bryn Culvert 1	A487 601 C73	1.8m Pipe	1.8m diameter proprietary concrete pipe.
S111	Pont Bryn Mafon	A487 611	Box Underbridge	In-situ reinforced concrete box structure with either in-situ reinforced concrete roof slab or a roof slab incorporating pre-cast concrete beams. 7.2m wide x 5.8m nominal internal opening.
S111A	Bryn Mafon Culvert 1	A487 611 C08	1.8m Pipe	1.8m diameter proprietary concrete pipe.
S111B	Bryn Mafon Culvert 2	A487 611 C09	1.5m Pipe	1.5m diameter proprietary concrete pipe.
S112	Pont Afon Seiont Newydd	A487 621	Viaduct	6 span steel concrete composite ladder deck superstructure continuous over reinforced concrete pier columns to each edge girder, with reinforced concrete cantilever abutments. Single span pre-cast pre-stressed concrete beam solid infill superstructure cast fully integral with reinforced concrete cantilever abutments over the A4085.
S112A	Bodrual Culvert 2	A487 621 C61	1.5m Pipe	1.5m diameter proprietary concrete pipe.
S112B	Bodrual Culvert 1	A487 621 C59	1.5m Pipe	1.5m diameter proprietary concrete pipe.
S113A	FP 36	A487 625	Box Underbridge	Proprietary pre-cast reinforced concrete box structure. 3.0m wide x 2.6m nominal internal opening.
S114	Afon Cadnant Cattle Creep / Culvert	A487 631	Box Underbridge	Proprietary pre-cast reinforced concrete box structure. 3.4m wide x 3.4m nominal internal opening.
S114A	Lon Glai Culvert	A487 631 C08	1.8m Pipe	1.8m diameter proprietary concrete pipe.
S115	Bethel Road Overbridge	A487 635	Overbridge	Single span pre-cast pre-stressed concrete beam and slab superstructure cast fully integral with deck end bankseats, supported on reinforced soil substructures incorporating vertical pre-cast concrete fascia panels.
S115A	Bethel Road Culvert 1	A487 635 C01	1.8m Pipe	1.8m diameter proprietary concrete pipe.

Structure	WG Structure Name	WG Asset No.	Type	Recommended Structural Form and Materials
S115B	Bethel Road Culvert 2	A487 635 C03	1.8m Pipe	1.8m diameter proprietary concrete pipe.
ADS	TBC	TBC	Sign posts & foundations	Proprietary posts and in-situ concrete gravity foundations.

APPENDIX A – WHR LOAD & STRUCTURE GAUGE



NOTE 'A' THIS DIMENSION RELATES TO BRIDGES NOT MORE THAN 25M LONG WITHOUT RECESSES, THE NEAREST FACE OF SIGNAL POSTS AND OTHER ISOLATED STRUCTURES LESS THAN 2M LONG. EXISTING TUNNELS OF THIS WIDTH MUST BE PROVIDED WITH SAFETY RECESSES AT STANDARD SPACING.

NOTE 'B' THIS DIMENSION RELATES TO BOTH STRUCTURES AND FENCE LINES AND SHOULD BE USED WHEREVER PRACTICABLE

NOTE 'C' THIS DIMENSION RELATES TO ISOLATED PLATFORM LIGHTING OR CANOPY COLUMNS

NOTE 'D' WHERE THIS DIMENSION IS LESS THAN 100MM THE TRACK MUST BE POSITIVELY LOCATED (ABSOLUTE MINIMUM: 50mm)

NOTE 'E' THIS DIMENSION RELATES TO PLATFORM BUILDINGS OR OTHER SOLID STRUCTURES

NOTE 'F' THIS DIMENSION RELATES TO THE CLEARANCE REQUIRED TO THE UNDERSIDE OF CANOPIES, SIGNS ETC.

NOTE 'G' ALL OVERHEAD TELEGRAPH AND ELECTRICAL CABLES MUST BE AT LEAST 5M ABOVE RAIL LEVEL.

NOTE 'H' ALL DIMENSIONS SHOWN ARE FOR STRAIGHT TRACK AND MAKE NO ALLOWANCE FOR CURVATURE OR TRACK SUPERELEVATION. ADDITIONAL ALLOWANCES MUST BE CALCULATED FOR CURVES AND ADDED TO THE GIVEN DIMENSIONS. THE EXTRA ALLOWANCE REQUIRED FOR CURVATURE ALONE BASED ON A VEHICLE 13M LONG AND WITH 8,65M BOGIE CENTRES IS AS FOLLOWS:–

OUTSIDE OF CURVE MM WIDTH	CURVE RADIUS M RAD	INSIDE OF CURVE MM WIDTH
290	40	230
235	50	187
196	60	156
168	70	134
147	80	117
131	90	104
118	100	94
98	120	78
84	140	67
73	160	58
59	200	52
49	240	47

NOTE 'I' DISTANCE FROM TRACK CENTRELINE TO PLATFORM EDGE TO REMAIN CONSTANT THROUGH ALL CURVES. ROLLING STOCK TO BE DESIGNED TO CLEAR ALL PLATFORM EDGES DOWN TO 50M RADIUS.

A3

SCALE 1:20

PROJECTION THIRD ANGLE

ALL DIMENSIONS ARE IN MILLIMETERS

IF IN DOUBT – ASK!

DO NOT SCALE FOR EXPL^N OF DIM^S & NOTES ETC, SEE B.S. 308.

ISSUING OFFICERS: DFH & JAW

This drawing remains the property of the Festiniog Railway Co. and MUST NOT be communicated to a 3rd party, copied or stored mechanically or electronically in a retrievable system without the prior written permission of the Festiniog Railway Company.

REV.	BY	CHKD	DATE	APP'D	GRID REF	REVISIONS	PRE PREFIX OR VAR No.

NOTE: ALTHOUGH DIMENSIONS IN mm, DRAWN IN AUTOCAD IN METRES

Computer File: BOSTONLODGE\DATA\DRAWINGS\LOADING\PW30A

FESTINIOG RAILWAY COMPANY
CIVIL ENGINEERING DEPARTMENT
PORTHMADOG

TITLE LOAD & STRUCTURE GAUGE (WELSH HIGHLAND SECTION)

Scale:–1:20 | Drawn:– RMED | Checked:– JAW & DFH | Issue: A

Contract No:–

Drg No:– PW30A

Issue Date:– 10/02/06

APPENDIX B – OUTLINE FOUNDATION SCHEDULE

Structure	WG Structure Name	WG Asset No.	Type	Recommended Structural Form and Materials	Proposed Foundations and Geotechnical Considerations	Exploratory holes
S101	Ty Hên Culvert	A487 550 C68	1.8m Pipe	1.8m diameter proprietary concrete pipe.	No Engineers logs available. Assume bedding.	BH01
S101A	Pont Parc Underpass	A487 561	Box Underbridge	In-situ reinforced concrete box structure with either in-situ reinforced concrete roof slab or a roof slab incorporating pre-cast concrete beams. 7.2m wide x 5.8m high nominal internal opening.	No Engineers logs available. Based upon the drillers logs and reported SPT N values at 1.0m BGL spread footings would develop a safe bearing resistance of 175 kPa, at 2.0m 200 kPa. Any ground improvement required below structure to be confirmed following receipt of ground investigation data and associated testing.	BH02, 03
S102	Afon Rhyd Culvert	A487 565	Box Culvert	In-situ or proprietary pre-cast reinforced concrete box culvert. 3.2m wide x 1.8m high nominal internal opening.	Engineer's logs available. Any ground improvement required below the structure to be confirmed following receipt of laboratory testing.	BH04, 05
S103	Ty'n Llan Overbridge	A487 571	Overbridge	3 span pre-cast pre-stressed concrete beam superstructure made fully integral with 2 no. reinforced concrete piers and 2 no. bankseat abutments.	Engineer's logs available. Based upon logs and recorded SPT N values at 2.0m spread footings would develop a safe bearing resistance of 150 kPa. Alternatively bored cast in place piles could be adopted founded in the weathered Rhyolite at approximately 5.0m. While not recorded in the logs based upon the re-drills required cobbles/boulder are present that are likely to preclude the use of CFA or driven piles.	BH06, 07
S104	Geufron Culvert	A487 571 C80	1.8m Pipe	1.8m diameter proprietary concrete pipe.	No information. Assume bedding.	-

Structure	WG Structure Name	WG Asset No.	Type	Recommended Structural Form and Materials	Proposed Foundations and Geotechnical Considerations	Exploratory holes
S105	Dinas Accommodation Underpass	A487 575	Box Underbridge	In-situ reinforced concrete box structure with either in-situ reinforced concrete roof slab or a roof slab incorporating pre-cast concrete beams. 4.5m wide x 4.65m high nominal internal opening.	No Engineers logs available. Any requirement for ground improvement below structure to be confirmed following receipt of ground investigation data and associated laboratory testing.	BH10, 11, 12, 13
S106	Afon Gwyrfai Viaduct	A487 581	Viaduct	8 span steel concrete composite multi-beam superstructure continuous over reinforced concrete leaf piers, with reinforced concrete cantilever abutments.	Limited GI available. Based upon results available spread footing at 2.5m BGL 3.0m wide will develop a safe bearing resistance of 350 kPa.	BH14 – 28 TP15 - 20
S107	Pont Llydiart Gwyn	A487 585	Box Underbridge	In-situ reinforced concrete box structure with either in-situ reinforced concrete roof slab or a roof slab incorporating pre-cast concrete beams. 7.2m wide x 5.8m high nominal internal opening.	Based upon results available spread footing at 2.0m BGL 3.0m wide will develop a safe bearing resistance of 450 kPa.	BH29, 30
S108	Pont Cefnwerthyd	A487 591	Underbridge	Single span pre-cast pre-stressed concrete beam solid infill superstructure cast fully integral with deck end bankseats, supported on reinforced soil substructures incorporating vertical pre-cast concrete fascia panels.	Either piled supports to the reinforced concrete deck end bankseats, linked via reinforced concrete columns sleeved through the reinforced soil abutments. Piled foundations, bearing on weathered rhyolite at 7.0 to 10.0m. Presence of cobbles could preclude the use of CFA or driven piles. Or reinforced concrete deck end bankseats founded on spread footings above reinforced soil abutments, with ground improvement below the reinforced soil substructures.	BH31 - 34

S109	Pont Ceriw NMU Overbridge	A487 601	Overbridge	Single span pre-cast pre-stressed concrete beam solid infill superstructure cast fully integral with deck end bankseats, supported on reinforced soil substructures incorporating vertical pre-cast concrete fascia panels.	Based upon a single exploratory hole. Either piled supports to the reinforced concrete deck end bankseats, linked via reinforced concrete columns sleeved through the reinforced soil abutments. Piled foundations, bearing on weathered rhyolite at 10.0m. Or reinforced concrete deck end bankseats founded on spread footings above reinforced soil abutments, with ground improvement below the reinforced soil substructures.	BH35 - 38
S109A	Pen Y Bryn Culvert 3	A487 601 C01	1.8m Pipe	1.8m diameter proprietary concrete pipe.	No information. Assume bedding.	?
S110A	Pen Y Bryn Culvert 2	A487601 C58	1.8m Pipe	1.8m diameter proprietary concrete pipe.	No information. Assume bedding.	?
S110	Pen y Bryn Culvert 1	A487 601 C73	1.8m Pipe	1.8m diameter proprietary concrete pipe.	Assume bedding, settlements are potentially an issue due to soft/weak soils.	TP36
S111	Pont Bryn Mafon	A487 611	Box Underbridge	In-situ reinforced concrete box structure with either in-situ reinforced concrete roof slab or a roof slab incorporating pre-cast concrete beams. 7.2m wide x 5.8m nominal internal opening.	No information available. Any requirement for ground improvement below structure to be confirmed following receipt of ground investigation data and associated laboratory testing.	BH40, 41
S111A	Bryn Mafon Culvert 1	A487 611 C08	1.8m Pipe	1.8m diameter proprietary concrete pipe.	No information. Assume bedding.	TP40
S111B	Bryn Mafon Culvert 2	A487 611 C09	1.5m Pipe	1.5m diameter proprietary concrete pipe.	No information. Assume bedding.	?

S112	Pont Afon Seiont Newydd	A487 621	Viaduct	6 span steel concrete composite ladder deck superstructure simply supported on and continuous over reinforced concrete pier columns to each edge girder, with reinforced concrete cantilever abutments. Single span pre-cast pre-stressed concrete solid infill superstructure cast fully integral with reinforced concrete cantilever abutments.	Geotechnical data limited to south side of Afon Seiont. Boreholes only available in area of northern bank seat/abutment. South of Afon Seiont spread footings at 2.5m BGL would develop a bearing resistance of around 400 kPa. Alternatively bored cast in place piles could be adopted founded in the weathered shale at approximately 5.0m, due to the potential for cobbles/boulder being present that are likely to preclude the use of CFA or driven piles.	BH45 - 62
S112A	Bodrual Culvert 2	A487 621 C61	1.5m Pipe	1.5m diameter proprietary concrete pipe.	No information. Assume bedding.	?
S112B	Bodrual Culvert 1	A487 621 C59	1.5m Pipe	1.5m diameter proprietary concrete pipe.	No information. Assume bedding.	_
S113A	FP 36	A487 625	Box Underbridge	Proprietary pre-cast reinforced concrete box structure. 3.0m wide x 2.6m nominal internal opening.	No information available. Any requirement for ground improvement below structure to be confirmed following receipt of ground investigation data and associated laboratory testing.	?
S114	Afon Cadnant Cattle Creep / Culvert	A487 631	Box Underbridge	Proprietary pre-cast reinforced concrete box structure. 3.4m wide x 3.4m nominal internal opening.	Based upon results of single exploratory hole spread footing at 2.0m BGL will develop a safe bearing resistance of 350 kPa.	TP71
S114A	Lon Glai Culvert	A487 631 C08	1.8m Pipe	1.8m diameter proprietary concrete pipe.	No information. Assume bedding.	?

S115	Bethel Road Overbridge	A487 635	Overbridge	Single span pre-cast pre-stressed concrete beam and slab superstructure cast fully integral with deck end bankseats, supported on reinforced soil substructures incorporating vertical pre-cast concrete fascia panels.	Either piled supports to the reinforced concrete deck end bankseats, linked via reinforced concrete columns sleeved through the reinforced soil abutments. Piled foundations, bearing on weathered shales at 5.0 to 7.0m as a result of soft/compressible soils. Or reinforced concrete deck end bankseats founded on spread footings above reinforced soil abutments, with ground improvement below the reinforced soil substructures.	BH74, 76, 77
S115A	Bethel Road Culvert 1	A487 635 C01	1.8m Pipe	1.8m diameter proprietary concrete pipe.	No information. Assume bedding.	?
S115B	Behal Road Culvert 2	A487 635 C03	1.8m Pipe	1.8m diameter proprietary concrete pipe.	No information. Assume bedding.	?
ADS	TBC	TBC	Sign posts & foundations	Proprietary posts and in-situ concrete gravity foundations.	Likely in-situ concrete gravity foundations.	?

APPENDIX C – COMPARATIVE CAPITAL AND WHOLE LIFE COSTS

Introduction

This appendix provides supporting information to the main body as to how capital maintenance and whole life costs have been developed with sections describing:

- Capital works costs for the structures options considered;
- Maintenance interventions and cost of these interventions for the options considered;
- Whole life cost analysis;
- Summary and conclusions.

The following structure types/structures have been specifically identified for review of whole life costs: Overbridges, S109 Pont Ceriw NMU Overbridge, S106 Afon Gwyrfai Viaduct and S112 Pont Afon Seiont Newydd.

Given the options considered for the underbridges are all of concrete construction, whole life costing of options was not undertaken and comparative capital costs are presented only.

Background to Whole Life Costing

There are a number of definitions for whole life cycle costing, but one currently adopted is:

"The systematic consideration of all relevant costs and revenues associated with the acquisition and ownership of an asset."

Essentially whole life costing (WLC) is a means of comparing options and their associated cost and income streams over a period of time. Costs to be taken into account include both initial capital or procurement costs, opportunity costs and future costs. Only options which meet the performance requirements for the built asset should be considered – those with lower costs over the period will be preferred.

Initial costs include design, construction and installation, purchase or leasing, fees and charges.

Future costs include all operating costs, such as rent, rates, cleaning, inspection, maintenance, repair, replacements / renewals, energy and utilities use, dismantling, disposal, security and management over the life of the built asset. Loss of revenue may also need to be taken into account – for example to reflect the non-availability of a revenue-generating building during maintenance work for example.

The timing of future costs must be taken into account in the comparison of options. Future cost flows are discounted by a rate that relates present and future money values – which may include an allowance for inflationary changes.

In the context of structures asset management, for a new asset, initial costs will be considered to include the costs of design and construction of the asset – the capital works cost. Future costs will be considered to include costs relating to inspection and maintenance of the asset over its working life.

Whilst, for short term budget planning, it might be advantageous to have solutions which have lowest initial capital cost, increasingly asset management organisations require solutions which account for the future costs of maintenance. Such solutions are also more likely to satisfy the requirements for sustainability.

The optimal solution may be considered that having lowest initial capital costs and lowest whole life costs.

BD2/12 Technical Approval of Highway Structures makes specific reference to the need for design options to have considered maintenance and operational commitments in terms of whole life costs, with such being included in the Approval in Principle document.

Hence, in the preparation of the Design Options Report, whole life costs have been critically considered in the comparison of the structures options, alongside other selection criteria.

Comparative Initial Capital Works Costs

Balfour Beatty Jones Brothers Joint Venture (BBJB) has estimated construction costs for design options in support of the Structures Design Options Report. In so doing, account has been taken of the following principal items:

- Material costs
- Overall construction methodology
- Construction programme

In order to allow relatively rapid determination of options for comparative costing purposes, principal structural element sizes have typically been determined from available look-up tables and/or manufacturers' data sheets, blended with experience of similar structural forms on other highway schemes.

Whilst Capital Works Costs have been estimated on a similar basis to those determined at tender, they have been assimilated for the express purpose of comparison between options.

BBJB's capital works cost estimates are raw costs, and typically exclude allowances for preliminaries, contingency and profit, except where they provide a marked difference between options.

For Overbridges, the following is noted:

- At the time of the cost estimate being prepared, the basis of the outline design in advance of receipt of any GI was a spread foundation for all substructures.
- Solutions incorporating reinforced soil abutments have included for the bank seats being supported on piles/columns sleeved through the reinforced earth backfill. However, subject to receipt of GI, it is confidently predicted that such piles/columns can be omitted and hence the capital costs for solutions including reinforced soil abutments are therefore overestimated by comparison.
- For the single 20m span solutions, capital costs are based on wing walls parallel with the A487 mainline. However, it is likely that wing walls will be angled at 45 degrees, reducing the length of the wing wall and hence the capital costs for these options are overestimated.

For S109, the following is noted:

- The pricing represents the cost of the structure only and any effects to approach embankments have not be taken into account, nor any haul road diversions required for construction of particular options.

For S106, the following is noted:

- At the time of the cost estimate being prepared, the basis of the outline design in advance of receipt of any GI was a piled foundation for all substructures. However, no allowance has been made for the difference between foundations for the steel composite solution compared with the heavier pre-cast concrete solution. Capital works costs for the pre-cast concrete solution are therefore under-estimated by comparison.

Summary of Capital Costs

Underbridges

Capital works costs were produced for each of the options considered for the Underbridges, as described in the main body of this report. The table below summarises these.

	Superstructure Materials			
	In-situ reinforced concrete box	**In-situ reinforced concrete box incorporating pre-cast deck elements**	**Opti-Cadre Box**	**Arch and Portal forms**
	Option 1	**Option 2**	**Option 3**	**Options 4 & 5**
Capital Cost	£384,000	£425,000	£534,000	N/A

Overbridges

Capital works costs were produced for each of the options considered for the Overbridges, as described in the main body of this report. The table below summarises these.

	Superstructure Materials			
Span arrangement	**Steel concrete composite multi-beam deck**	**Steel concrete composite ladder deck**	**Pre-cast pre-stressed concrete beam deck**	**In-situ reinforced concrete deck**
3 span superstructure	**Option 1**	**Option 2**	**Option 3**	**Option 4**
Capital Cost in Cut	£431,000	N/A	£494,000	£538,000
Capital Cost in fill	£431,000	N/A	£519,000	£550,000
c.20m single span superstructure Reinforced Soil abutments (wingwalls in line with A487)	**Option 5**	**Option 6**	**Option 7**	**Option 8**
Capital Cost in Cut	£417,000	N/A	£425,000	N/A
Capital Cost in fill	£429,000	N/A	£438,000	N/A
Reinforced Concrete abutments (wingwalls in line with A487)				
Capital Cost in Cut	£432,000	N/A	£458,000	N/A
Capital Cost in fill	£444,000	N/A	£471,000	N/A
c.30m single span superstructure	**Option 9**	**Option 10**	**Option 11**	**Option 12**
Capital Cost in Cut	£504,000	£515,000	£492,000	N/A
Capital Cost in fill	£516,000	£540,000	£517,000	N/A

S109 Pont Ceriw NMU Overbridge

Capital works costs were produced for each of the options considered for S109 Pont Ceriw Overbridge, as described in the main body of this report. The table below summarises these.

	Superstructure Materials		
	Pre-cast pre-stressed concrete beam deck	**3-span RC**	**36m span steel truss**
	Option 1	**Option 2**	**Option 3**
Capital Cost	£229,000	£239,000	£264,000

S106 Afon Gwyrfai Viaduct

Capital works costs were produced for each of the options considered for S106 Afon Gwyrfai Viaduct, as described in the main body of this report. The table below summarises these.

	Superstructure Materials			
Span arrangement	**Steel concrete composite multi-beam deck**	**Steel concrete composite ladder deck**	**Pre-cast pre-stressed concrete beam deck**	**In-situ reinforced concrete deck**
8No 32.5m Spans	**Option 1**	**Option 2**	**Option 3**	**Option 4**
Capital Cost	£4,172,000	N/A	£5,010,000	N/A

S112 Pont Afon Seiont Newydd

Capital works costs were produced for each of the options considered for S112 Pont Afon Seiont Newydd, as described in the main body of this report. The table below summarises these.

	Superstructure Materials				
Span arrangement	**Steel concrete composite multi-beam deck**	**Steel concrete composite ladder deck**	**Steel concrete composite box girder deck**	**Pre-cast pre-stressed concrete beam deck**	**Post-tensioned concrete deck**
	Option 1	**Option 2**	**Option 3**	**Option 4**	**Option 5**
Capital Cost	N/A	£5,356,000	N/A	£7,222,000	£13,000,000

Comparative Maintenance Costs

In the preparation of the Structures Design Options Report, informal discussions were held with a number of specialist painting contractors to determine the costs of maintenance including access.

The form of the information received from suppliers varied. Some offered "all-in" budget rates for access and maintenance works based on surface area of steel to be treated, in the case of steel/concrete composite bridges. Others gave budget sums for individual structures based on sketches provided with the costs separated out for access and painting

Notwithstanding, in general, good agreement was achieved for structure types and particular structures using both approaches.

It should be noted that all maintenance costs determined through engagement with the supply chain are budget estimates which, by their nature, include allowances for contingency and profit. As such, the maintenance costs are skewed compared with the capital works costs, to the relative dis-benefit of the steel/concrete composite structural forms.

Conversely, the budget costs from the suppliers have not all included preliminaries including temporary access roads, payments to landowners affected by the works, site security and costs associated with establishment of a site compound, and hence are beneficial to the steel/concrete composite structural forms.

For the purposes of this exercise, costs associated with the inspection of the structures have not been considered. It is considered that the cost and frequency of inspections associated with the structures is comparable irrespective of structural form.

Maintenance Strategies for Structure Forms Considered

Steel & Steel/Concrete Composite Superstructure Options

The paint treatment to new steel bridges is specified in accordance with the *Specification for Highway Works* Series 1900.

Table NG19/1 of the *Notes for Guidance on the Specification for Highway Works Series NG1900* indicates a Type II protective system is considered appropriate for the main steelwork of bridge structures proposed with "difficult access".

Such protective systems should not generally require any maintenance up to 12 years. Minor maintenance may be required from 12 years to ensure that the system will continue to perform satisfactorily up to 20 years, whereupon major maintenance of the protective treatment system will be required.

It should be noted that Network Rail standard *NR/GN/CIV/002 The Use of Protective Coatings and Sealings* indicates a service life for the comparable paint system ("N2") of 20 to 25 years.

Maintenance costs for steel/concrete composite superstructure options are based on the above with maintenance interventions as described below.

For the purposes of these costs, the cost of the maintenance painting of bearings is assumed to be included within the overall structure maintenance costs as such maintenance will be carried out at the same time using the same access.

Minor Maintenance (12 year intervals) - Mid-term Maintenance:

Mid-term minor maintenance painting programme to areas of coating deterioration comprising touch up only to inner beams and touch up and full cosmetic coat to outer faces of edge beams using MEWPs for access. It is assumed that there is no more than 10% breakdown of coatings.

Major Maintenance (25 year intervals) - Renewal of Protective Treatment System:

Carry out full re-coating of structure, including removal of all existing coatings down to sound metal coating or bare steel (grit blasting to SA2), followed by repainting with 3 or 4-coat system in accordance with *Specification for Highway Works* Series 5000.

Access and Traffic Management Arrangements:

The feedback from the supply chain indicates the following likely arrangements for access and traffic management.

Overbridges and NMU Overbridge

Based on maintaining a 2-way flow of traffic on the A487 whilst the overbridge is repainted, it was assumed that the works would have to be undertaken in a number of phases with appropriate provision of traffic management and safety zones.

The prices received from suppliers assumed that the overbridges would be treated in 2 phases, however it is likely that 3 phases will be required due to the available carriageway width and consideration of traffic management and safety zones for 2-way traffic and hence the maintenance costs may be under-estimated as they do not reflect fully the anticipated project duration.

It has been assumed that access would be via MEWPs from ground level for the minor maintenance and via scaffolding from ground level for the major maintenance.

For the major maintenance, to ensure containment of water spray and other waste materials arising from the works, the scaffolding would be fully encapsulated.

Traffic management costs have not been included in the cost of repainting as it is assumed that these works would be programmed to coincide with other maintenance works on the A487 for which traffic management would be shared.

Viaducts

With both the Afon Gwyrfai Viaduct and Pont Afon Seiont Newydd carrying the A487 mainline across open land, access would be erected, moved and dismantled completely from beneath the structure, which avoids the need for any works or access to the carriageway above. As a result, it should not be necessary to implement any temporary traffic management measures on the A487 to undertake the maintenance painting works.

Afon Gwyrfai Viaduct

With the structure being relatively close to ground level (approximately 3 to 4 metres from ground level to the beam soffits), access for maintenance has been assumed to be directly from the ground. Hence, for minor maintenance, MEWPs have been considered, and for major maintenance, scaffolding.

For the major maintenance, to ensure containment of water spray and other waste materials arising from the works, the scaffolding would be fully encapsulated (this would need to be subject to NRW consent to avoid polluting watercourses).

For the full repainting options, it is likely that the scaffolding would extend over two spans at any time. This would be moved along the structure as the work progressed. However, given that the scaffold would be supported off the ground, the scaffold could be extended across more spans without having concern for any loads applied to the superstructure.

Pont Afon Seiont Newydd

The viaduct is relatively high above ground level (approximately 15m from ground level to the beam soffits at its maximum), and access for major maintenance has been assumed to be via scaffolding suspended from the main girders. For minor maintenance, access has been assumed to be from MEWPs.

For the major maintenance, to ensure containment of water spray and other waste materials arising from the works, the scaffolding would be fully encapsulated (this would need to be subject to NRW consent to avoid polluting watercourses).

For the full repainting options, it is likely that the scaffolding would extend over two spans at any time. This would be moved along the structure as the work progressed. At this stage, this is considered to represent an acceptable balance between the additional loading on the structure which can be allowed for in the normal reserve of strength under a “transient” design situation, without impacting on the overall ability of the viaduct to carry full traffic loads.

Indicative Costs of Maintenance Painting Activities:

As noted above, information received from the supply chain provided budget costs of maintenance painting and associated provision of access for both minor and major maintenance interventions, either in the form of an “all-in” rate or separated out for access and painting.

Concrete Superstructures

For the purposes of whole life cost analysis, it has been assumed that no repairs are required to the concrete elements comprising the superstructure, i.e. treatment of spalls and cracks. It is assumed that both the specification and execution of the works produces a superstructure having negligible future maintenance liability, except for the protective treatment of mechanical bearings as described below.

Also not allowed for in any maintenance cost consideration is that of the reapplication of any surface impregnation materials such as “Pavix” or silane.

According to *BD43/03 The Impregnation of Reinforced and Pre-stressed Concrete Highway Structures Using Hyrophobic Pore-Lining Impregnants*, it is known from research evidence that impregnation with silane is highly effective for at least 15 years provided it is applied correctly, with longer service lives anticipated. However, BD43 suggests that it is advisable to assume that reapplication will be necessary after about 20 years.

For steel/concrete composite structure options, it is reasonable to assume that reapplication of surface impregnants could be undertaken as the same time as minor and major maintenance of the paint system.

Hence in this respect, the maintenance costs for concrete superstructure solutions are an under estimate for comparison purposes.

The concrete superstructure options for the Afon Gwyrfai Viaduct and Pont Afon Seiont Newydd require the use of mechanical bearings at support positions due to the provision of longitudinal continuity over intermediate supports.

These bearings comprise painted steel elements which will require maintenance of the protective treatment system over their lifetime, in the same way as the protective treatment system to larger painted steel elements, e.g. bridge girders, as described above.

In the calculation of the maintenance costs for concrete superstructures, allowance for painting of bearings has been included in a whole life cost analysis, in the absence of any other maintenance intervention on the structure where it could reasonably have been undertaken concurrently at little or no additional cost.

It has been assumed that renewal of the protective treatment system to bearings would be undertaken using MEWPs from ground level.

Since the form of access and general minor scope involved in repainting bearings was comparable with minor maintenance of the steel superstructure, the maintenance costs for painting the bearings of a concrete superstructure were estimated at 25% of this value.

Net Present Value of Maintenance Costs

Whole life cost analysis involves the cumulative net present value of maintenance activities being added to the construction costs.

This section set outs the methodology and results of the net present value analysis of maintenance costs.

Evaluation Period and Discount Rate

The evaluation period is the period over which the whole life cost calculation is performed. The evaluation period can be based on the expected life of the element or structure. However, for highway structures which are considered to be long life assets, it is more common for the evaluation period to be dictated by the discount rate. If a high discount rate is used, the costs are normally assessed over a 30 year period because costs beyond 30 years become negligible. If a low discount rate is used, the period may be extended to 60 years.

For this project, the whole life cost analysis was taken to be 60 years aligning with current recommendations from HM Treasury contained in the document *Green Book, Appraisal and Evaluation in Central Government*. This recommends a discount rate of 3.5% for the first 30 years and 3% for the remaining years.

Results

The tables below set out the results of the net present value (NPV) calculations of maintenance costs which have been undertaken based on the present day costs received from the supply chain with minor and major intervention periodicities as described above, i.e. 12 years, 25 years, 37 years and 50 years.

Overbridges

Discount rate for calculation of NPV:	**3.5%**	For the first 30 years
Discount rate for calculation of NPV:	**3.0%**	For the remaining years

Year:	**12**	**25**	**37**	**50**	**Total Cost:**
NPV factors	0.662	0.423	0.335	0.228	
Option 1 & Option 2 - 3-Span Overbridge			`		
Grit blasting and painting		£54,358		£54,358	
Scaffolding		£68,739		£68,739	
Mid Term Maintenance	£12,000		£12,000		
Total:	£12,000	£123,097	£12,000	£123,097	£270,194
Net Present Value:	£7,941	£52,088	£4,020	£28,079	**£92,129**

Year:	**12**	**25**	**37**	**50**	**Total Cost:**
NPV factors	0.662	0.423	0.335	0.228	
Option 5 - 20m Span Overbridge			`		
Grit blasting and painting		£39,578		£39,578	
Scaffolding		£32,078		£32,078	
Mid Term Maintenance	£10,000		£10,000		
Total:	£10,000	£71,656	£10,000	£71,656	£163,312
Net Present Value:	£6,618	£30,321	£3,350	£16,345	**£56,634**

Year:	**12**	**25**	**37**	**50**	**Total Cost:**
NPV factors	0.662	0.423	0.335	0.228	
Option 9 & Option 10 - 30m Span Overbridge			`		
Grit blasting and painting		£58,179		£58,179	
Scaffolding		£47,154		£47,154	
Mid Term Maintenance	£14,700.00		£14,700.00		
Total:	£14,700	£105,334	£14,700	£105,334	£240,068
Net Present Value:	£9,728	£44,572	£4,924	£24,028	**£83,252**

S109 Pont Ceriw NMU Overbridge

Discount rate for calculation of NPV:	**3.5%**	For the first 30 years
Discount rate for calculation of NPV:	**3.0%**	For the remaining years

Year:	**12**	**25**	**37**	**50**	**Total Cost:**
NPV factors	0.662	0.423	0.335	0.228	
Option 3 - 36m Span Steel Truss					
Grit blasting and painting		£39,578		£39,578	
Scaffolding		£32,078		£32,078	
Mid Term Maintenance	£10,000		£10,000		
Total:	£10,000	£71,656	£10,000	£71,656	£163,312
Net Present Value:	£6,618	£30,321	£3,350	£16,345	**£56,634**

S106 Afon Gwyrfai Viaduct

Discount rate for calculation of NPV:	**3.5%**	For the first 30 years
Discount rate for calculation of NPV:	**3.0%**	For the remaining years

Year:	**12**	**25**	**37**	**50**	**Total Cost:**
NPV factors	0.662	0.423	0.335	0.228	
Option 1 - Steel concrete composite multi-beam deck					
Grit blasting and painting		£393,750		£393,750	
Scaffolding		£483,032		£483,032	
Mid Term Maintenance	£81,941		£81,941		
Total:	£81,941	£876,782	£81,941	£876,782	£1,917,446
Net Present Value:	£54,227	£371,008	£27,449	£200,000	**£652,684**

Year:	**12**	**25**	**37**	**50**	**Total Cost:**
NPV factors	0.662	0.423	0.335	0.228	
Option 3 - Precast Prestressed Beam Deck					
Maintenance Painting of Bearings	£20,485	£20,485	£20,485	£20,485	£81,941
Net Present Value:	£13,557	£8,668	£6,862	£4,673	**£33,760**

S112 Pont Afon Seiont Newydd

Discount rate for calculation of NPV:	**3.5%**	For the first 30 years
Discount rate for calculation of NPV:	**3.0%**	For the remaining years

Year:	**12**	**25**	**37**	**50**	**Total Cost:**
NPV factors	0.662	0.423	0.335	0.228	
Option 2 - Steel concrete composite ladder beam deck			`		
Grit blasting and painting		£587,150		£587,150	
Scaffolding		£570,273		£570,273	
Mid Term Maintenance	£127,545		£127,545		
Total:	£127,545	£1,157,423	£127,545	£1,157,423	£2,569,936
Net Present Value:	£84,407	£489,760	£42,725	£264,016	**£880,909**

Year:	**12**	**25**	**37**	**50**	**Total Cost:**
NPV factors	0.662	0.423	0.335	0.228	
Option 3 - Precast Prestressed Beam Deck					
Maintenance Painting of Bearings	£31,886	£31,886	£31,886	£31,886	£127,545
Net Present Value:	£21,102	£13,493	£10,681	£7,273	**£52,549**

Comparative Whole Life Costings

Whole life cost comparison of structure options involves the addition of capital works costs to the cumulative net present value of maintenance invention costs.

This section combines the capital works costs and the net present value of maintenance costs presented in previous sections of this report.

Overbridges

	Superstructure Materials			
Span arrangement	Steel concrete composite multi-beam deck	Steel concrete composite ladder deck	Pre-cast pre-stressed concrete beam deck	In-situ reinforced concrete deck
3 span superstructure	**Option 1**	**Option 2**	**Option 3**	**Option 4**
Whole Life Cost in Cut	£523,000	N/A	£494,000	£538,000
Whole Life Cost in fill	£523,000	N/A	£519,000	£550,000
c.20m single span superstructure	**Option 5**	**Option 6**	**Option 7**	**Option 8**
Reinforced Soil abutments (wingwalls in line with A487)				
Whole Life Cost in Cut	£473,000	N/A	£425,000	N/A
Whole Life Cost in fill	£486,000	N/A	£438,000	N/A
Reinforced Concrete abutments (wingwalls in line with A487)				
Whole Life Cost in Cut	£488,000	N/A	£458,000	N/A
Whole Life Cost in fill	£501,000	N/A	£471,000	N/A
c.30m single span superstructure	**Option 9**	**Option 10**	**Option 11**	**Option 12**
Whole Life Cost in Cut	£587,000	£598,000	£492,000	N/A
Whole Life Cost in fill	£600,000	£623,000	£517,000	N/A

S109 Pont Ceriw NMU Overbridge

	Superstructure Materials		
	Pre-cast pre-stressed concrete beam deck	3-span RC	36m span steel truss
	Option 1	**Option 2**	**Option 3**
Whole Life Cost	£229,000	£239,000	£321,000

S106 Afon Gwyrfai Viaduct

	Superstructure Materials			
Span arrangement	Steel concrete composite multi-beam deck	Steel concrete composite ladder deck	Pre-cast pre-stressed concrete beam deck	In-situ reinforced concrete deck
8No 32.5m Spans	**Option 1**	**Option 2**	**Option 3**	**Option 4**
Whole Life Cost	£4,824,000	N/A	£5,043,000	N/A

S112 Pont Afon Seiont Newydd

	Superstructure Materials				
Span arrangement	Steel concrete composite multi-beam deck	Steel concrete composite ladder deck	Steel concrete composite box girder deck	Pre-cast pre-stressed concrete beam deck	Post-tensioned concrete deck
0	**Option 1**	**Option 2**	**Option 3**	**Option 4**	**Option 5**
Whole Life Cost	N/A	£6,237,000	N/A	£7,275,000	£13,053,000

Conclusions

Underbridges

Based on the summary of comparative capital works costs, in-situ reinforced concrete box solutions have lower capital works costs than in-situ options incorporating pre-cast elements or proprietary precast solutions.

Given the options considered for the underbridges being all of concrete construction, whole life costing of options was not undertaken and comparative capital costs are presented only, although the large number of joints for the proprietary precast solutions gives a perceived higher maintenance liability.

Overbridges

Based on the summary of comparative capital and whole life costs, structures having concrete superstructures generally have larger initial capital costs than steel alternatives but lower whole life costs.

Concrete superstructures can be more complex to construct with extended construction programmes compared with steel, but the benefits achieved by not having painted surfaces or bearings overcome this.

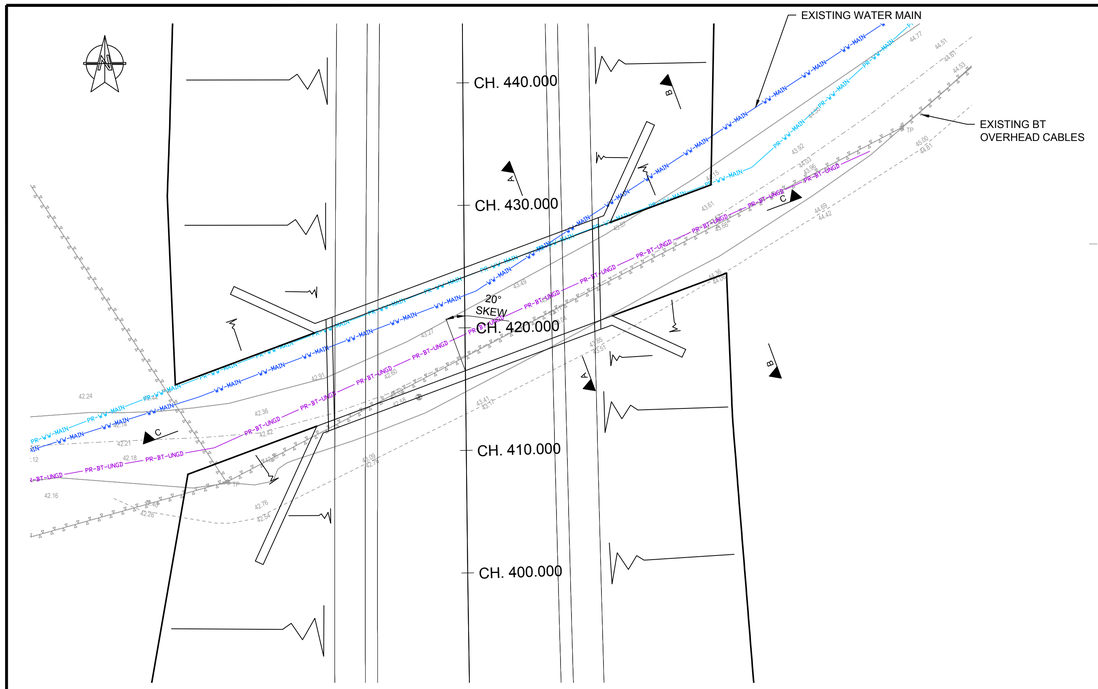
S109 Pont Ceriw NMU Overbridge

Based on the summary of comparative capital and whole life costs, a structure form comprising a single precast pre-stressed beam span supported on reinforced soil abutments has lower initial capital costs and lower whole life costs compared with the other options considered.

S106 Afon Gwyrfai Viaduct and S112 Pont Afon Seiont Newydd

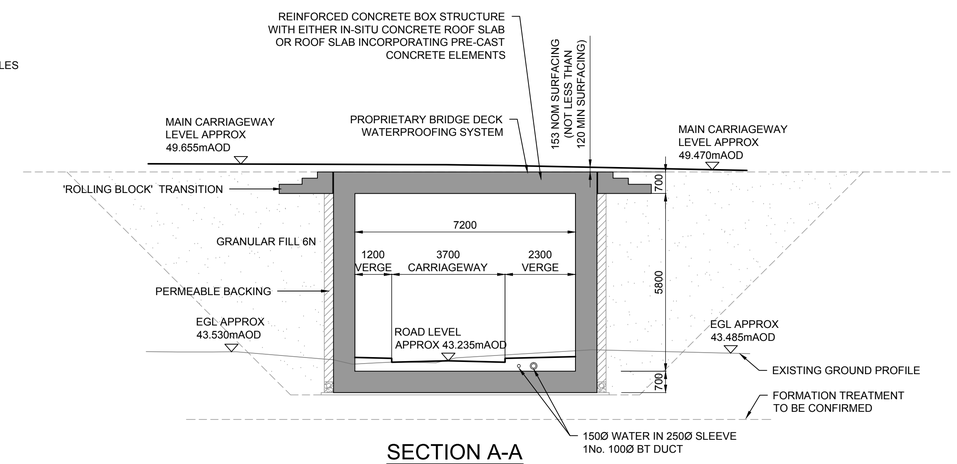
Based on the summary of comparative capital and whole life costs, structures having steel superstructures have lower initial capital costs than concrete alternatives and lower whole life costs. Whilst steel superstructures require maintenance to painted surfaces, the speed and relative simplicity of construction compared with concrete superstructures outweighs this dis-benefit.

APPENDIX D – GENERAL ARRANGEMENT DRAWINGS FOR RECOMMENDED SOLUTIONS



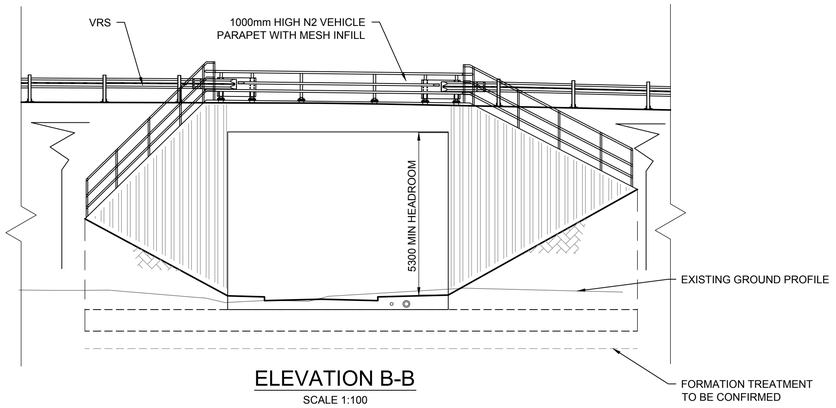
PLAN

SCALE 1:250



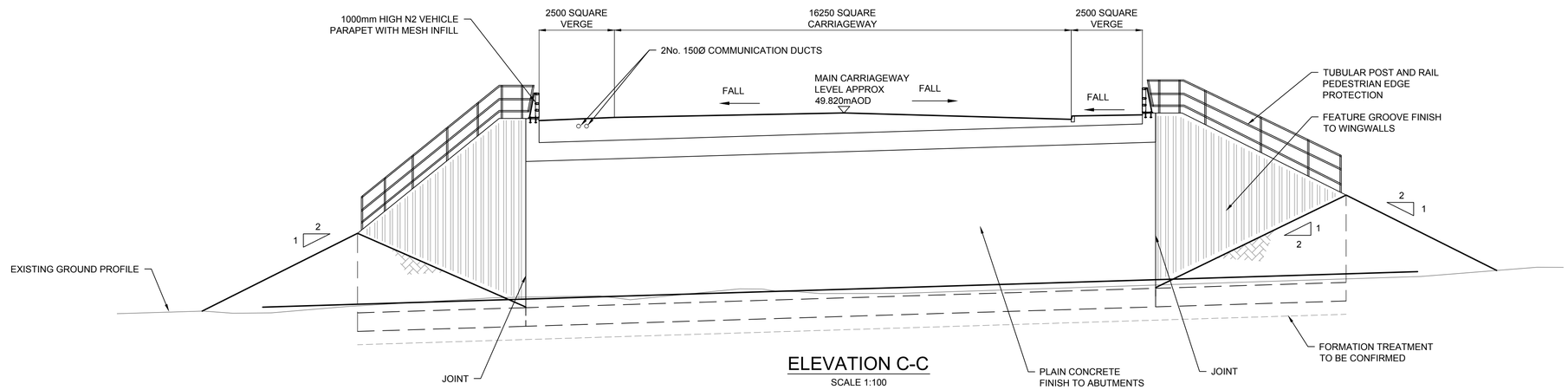
SECTION A-A

SCALE 1:100



ELEVATION B-B

SCALE 1:100



ELEVATION C-C

SCALE 1:100

© Crown copyright and database rights 2015
Ordnance Survey 0100031673
© Getmapping plc.

NOTES

A1

1. THIS IS A C.A.D. DRAWING AND SHOULD NOT BE AMENDED BY HAND.
2. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

HEALTH AND SAFETY INFORMATION

SIGNIFICANT OR EXCEPTIONAL RISKS ARE IDENTIFIED BELOW

CONSTRUCTION PHASE

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE WORKS INFORMATION FOR DETAILS OF THE RISKS ASSOCIATED WITH THIS WORK.
2. IN PREPARATION OF CONSTRUCTION METHOD STATEMENTS CONSIDERATION SHOULD BE GIVEN TO THE CLOSE PROXIMITY OF ANY STRUCTURES THAT MAY BE AFFECTED BY CONSTRUCTION.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE DRAWING.
   i. BEAM INSTABILITY DURING CONSTRUCTION.
4. THE CONTRACTOR SHALL REFER TO STATUTORY UNDERTAKERS LAYOUT DRAWINGS AND IDENTIFY LOCATIONS OF EXISTING UNDERGROUND SERVICES PRIOR TO CARRYING OUT EXCAVATION WORKS.

MAINTENANCE / OPERATION / DECOMMISSIONING / DEMOLITION PHASES

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE MAINTENANCE AND REPAIR STRATEGY FOR DETAILS OF THE RISKS ASSOCIATED WITH THE MAINTENANCE, OPERATION, DECOMMISSIONING AND DEMOLITION PHASES.
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE HEALTH AND SAFETY FILE(S) PRODUCED AND HANDED OVER ON COMPLETION OF THIS PROJECT.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE AS-BUILT DRAWING.
   i. NOTHING SIGNIFICANT OR UNUSUAL

Rev	Date	Description	By	Chk	App
P01	17/06/2015	FOR INFORMATION	MB	AMJ	AKG

FIT FOR INFORMATION

EC HARRIS BUILT ASSET CONSULTANCY
Llywodraeth Cymru Welsh Government
RAMBOLL
Balfour Beatty
JONES BROS CIVIL ENGINEERING UK
PARSONS BRINCKERHOFF
TACP
Ty Glyn, Canol Y Dre, Ruthin Denbighshire Tel: 01824 703661

Site/Project:

A487 CAERNARFON TO BONTNEWYDD BYPASS

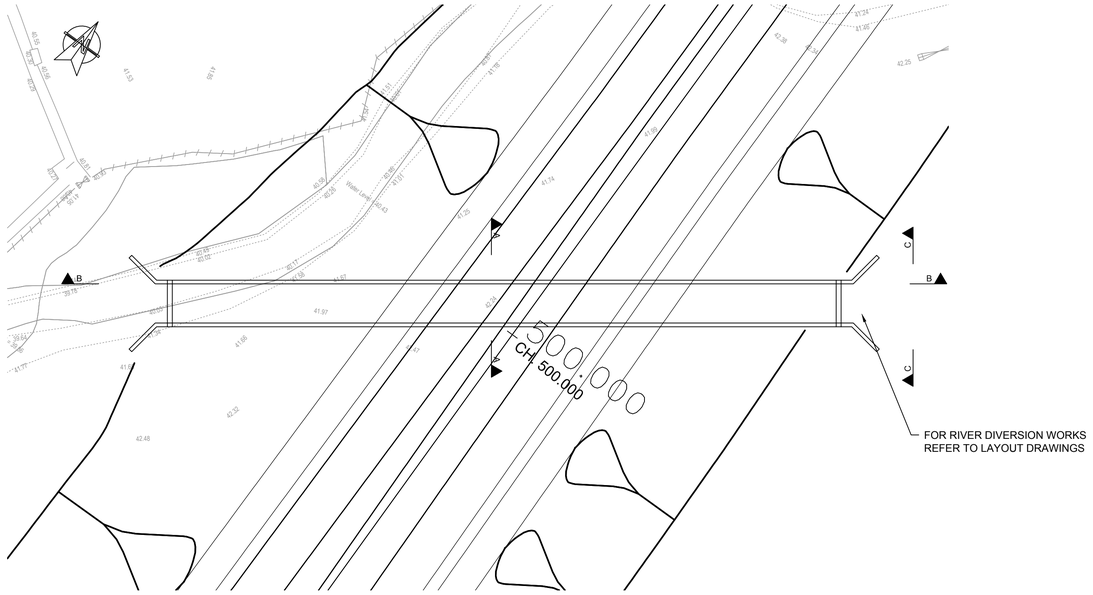
Title:

S101A PONT PARC UNDERPASS GENERAL ARRANGEMENT (WG No. A487 561)

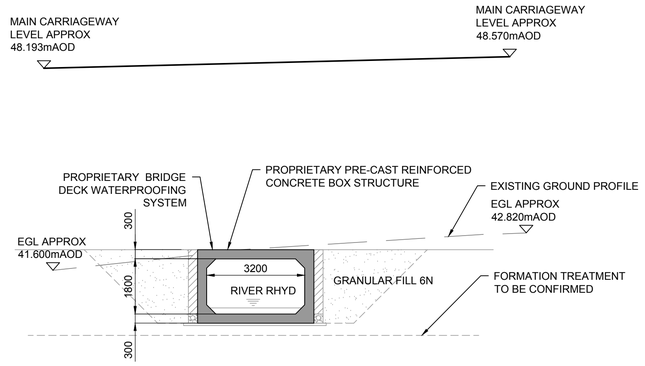
Drawn: M.Barka		Checked: A.Jarman	
Designed: A. GROVES		Approved: A.Groves	
Date: 10/06/15	Scale: AS SHOWN	A1	Sheet:

Container Number: 3513874-PB-SBR-101A-DR-S-00001 Revision: P01

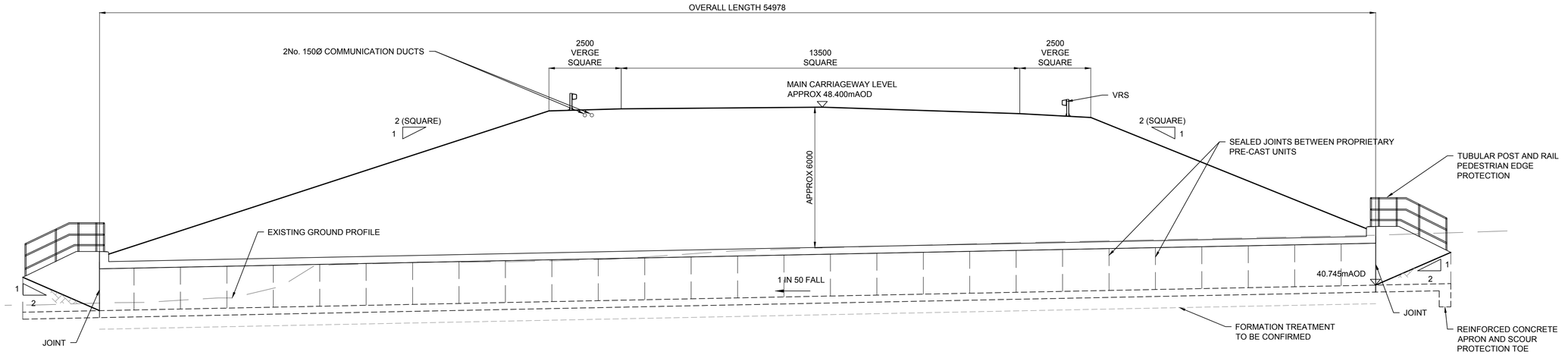
© Copyright Parsons Brinckerhoff



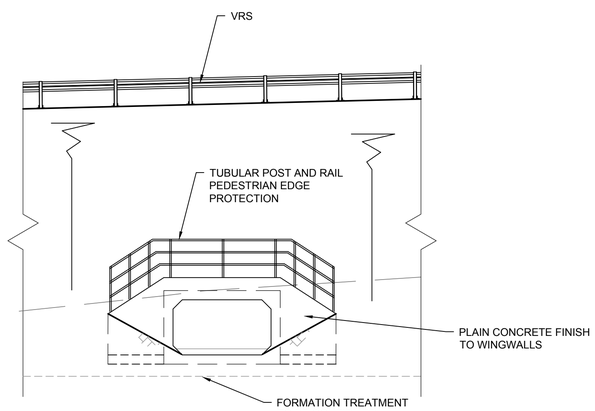
PLAN
SCALE 1:250



SECTION A-A
SCALE 1:100



SECTION B-B
SCALE 1:100



ELEVATION C-C
SCALE 1:100

© Crown copyright and database rights 2015
Ordnance Survey 0100031673
© Getmapping plc.

NOTES
A1

1. THIS IS A C.A.D. DRAWING AND SHOULD NOT BE AMENDED BY HAND.
2. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

HEALTH AND SAFETY INFORMATION

SIGNIFICANT OR EXCEPTIONAL RISKS ARE IDENTIFIED BELOW

CONSTRUCTION PHASE

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE WORKS INFORMATION FOR DETAILS OF THE RISKS ASSOCIATED WITH THIS WORK.
2. IN PREPARATION OF CONSTRUCTION METHOD STATEMENTS CONSIDERATION SHOULD BE GIVEN TO THE CLOSE PROXIMITY OF ANY STRUCTURES THAT MAY BE AFFECTED BY CONSTRUCTION.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE DRAWING.
   i. NOTHING SIGNIFICANT OR UNUSUAL.
4. THE CONTRACTOR SHALL REFER TO STATUTORY UNDERTAKERS LAYOUT DRAWINGS AND IDENTIFY LOCATIONS OF EXISTING UNDERGROUND SERVICES PRIOR TO CARRYING OUT EXCAVATION WORKS.

MAINTENANCE / OPERATION / DECOMMISSIONING / DEMOLITION PHASES

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE MAINTENANCE AND REPAIR STRATEGY FOR DETAILS OF THE RISKS ASSOCIATED WITH THE MAINTENANCE, OPERATION, DECOMMISSIONING AND DEMOLITION PHASES.
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE HEALTH AND SAFETY FILE(S) PRODUCED AND HANDED OVER ON COMPLETION OF THIS PROJECT.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE AS-BUILT DRAWING.
   i. NOTHING SIGNIFICANT OR UNUSUAL.

Rev	Date	Description	By	Chk	App
P01	12/06/2015	FOR INFORMATION	MB	AMJ	AKG

FIT FOR INFORMATION

EC HARRIS BUILT ASSET CONSULTANCY
Llywodraeth Cymru Welsh Government
RAMBOLL
Balfour Beatty
JONES BROS CIVIL ENGINEERING UK
PARSONS BRINCKERHOFF
TACP
Ty Glyn, Caroll Y Dre, Ruthin Denbighshire Tel: 01824 703661

Site/Project:

A487 CAERNARFON TO BONTNEWYDD BYPASS

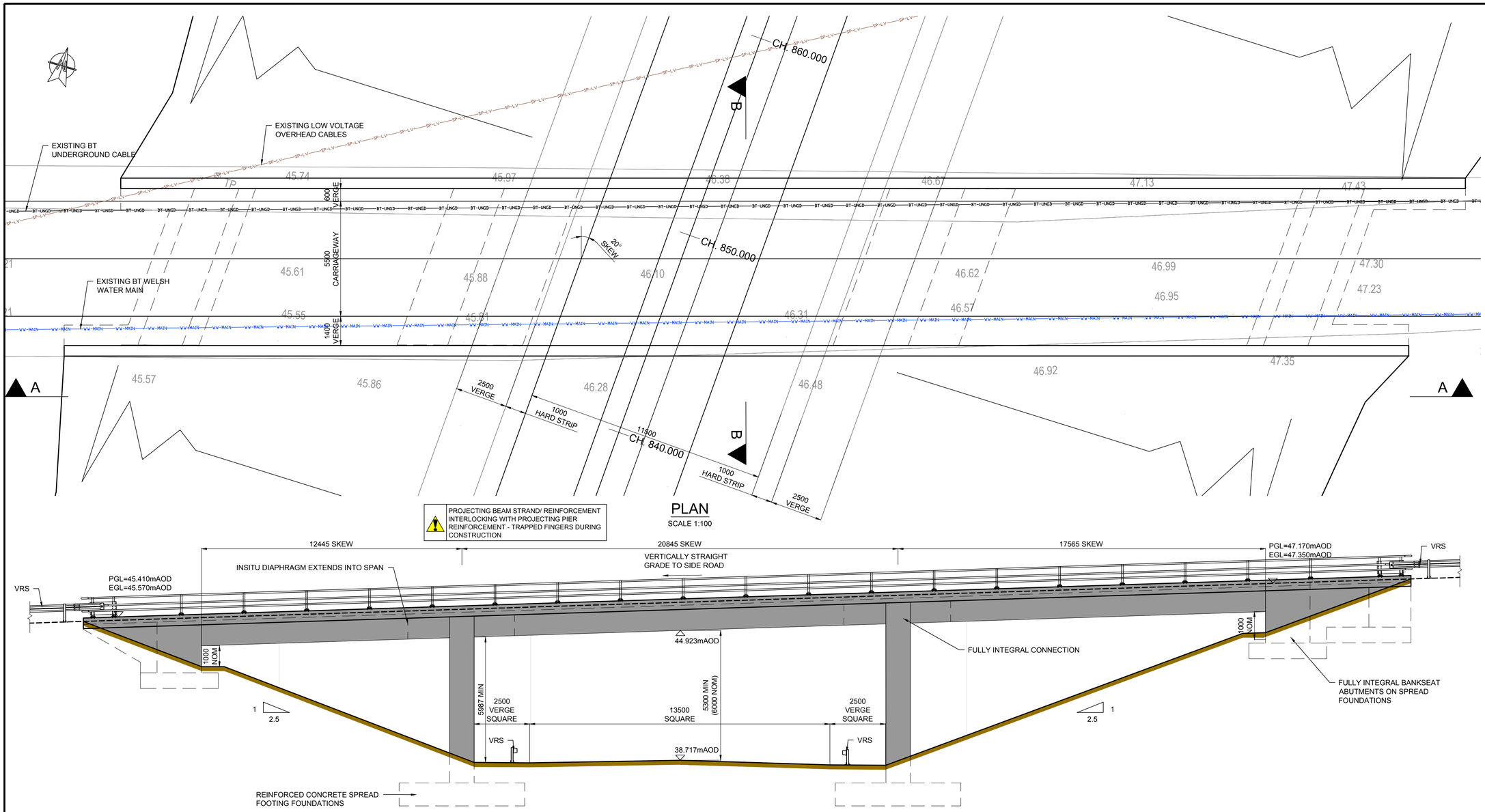
Title:

S102 AFON RHYD CULVERT GENERAL ARRANGEMENT (WG No. A487 565)

Drawn: M.Barka		Checked: A.Jarman	
Designed: A. GROVES		Approved: A.Groves	
Date: 09/06/15	Scale: AS SHOWN	A1	Sheet:

Container Number: 3513874-PB-SBR-102-DR-S-00001 Revision: P01

© Copyright Parsons Brinckerhoff



PLAN

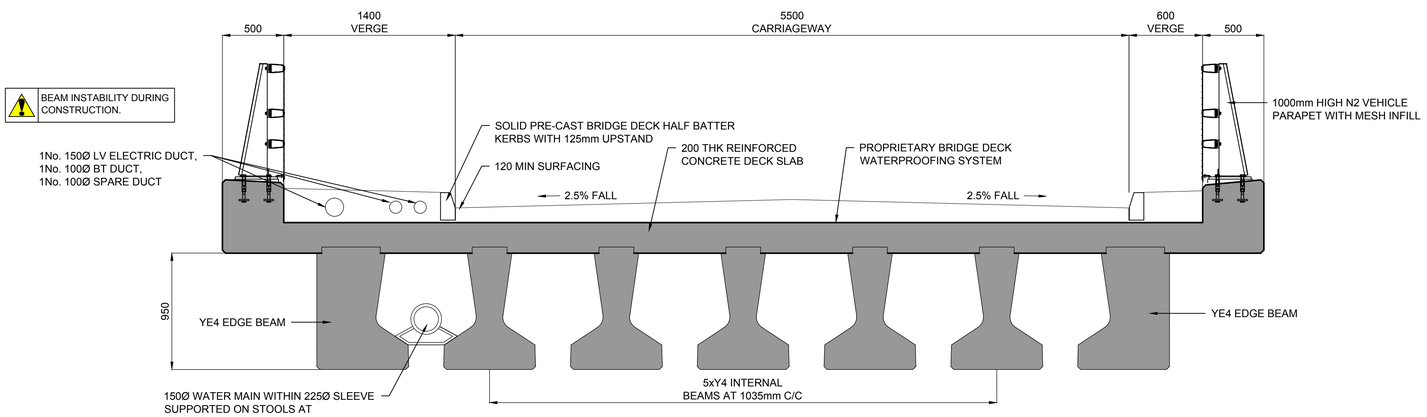
SCALE 1:100

PROJECTING BEAM STRAND/ REINFORCEMENT INTERLOCKING WITH PROJECTING PIER REINFORCEMENT - TRAPPED FINGERS DURING CONSTRUCTION

ELEVATION A-A

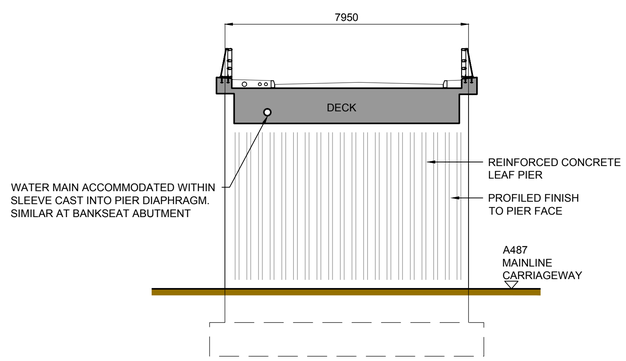
SCALE 1:100

BEAM INSTABILITY DURING CONSTRUCTION.



SECTION B-B

SCALE 1:25



ELEVATION ON PIERS

SCALE 1:100

© Crown copyright and database rights 2015 Ordnance Survey 0100031673
© Getmapping plc.

NOTES

A1

1. THIS IS A C.A.D. DRAWING AND SHOULD NOT BE AMENDED BY HAND.
2. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

HEALTH AND SAFETY INFORMATION

SIGNIFICANT OR EXCEPTIONAL RISKS ARE IDENTIFIED BELOW

CONSTRUCTION PHASE

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE WORKS INFORMATION FOR DETAILS OF THE RISKS ASSOCIATED WITH THIS WORK.
2. IN PREPARATION OF CONSTRUCTION METHOD STATEMENTS CONSIDERATION SHOULD BE GIVEN TO THE CLOSE PROXIMITY OF ANY STRUCTURES THAT MAY BE AFFECTED BY CONSTRUCTION.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE DRAWING.
   i. BEAM INSTABILITY DURING CONSTRUCTION.
4. THE CONTRACTOR SHALL REFER TO STATUTORY UNDERTAKERS LAYOUT DRAWINGS AND IDENTIFY LOCATIONS OF EXISTING UNDERGROUND SERVICES PRIOR TO CARRYING OUT EXCAVATION WORKS.

MAINTENANCE / OPERATION / DECOMMISSIONING / DEMOLITION PHASES

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE MAINTENANCE AND REPAIR STRATEGY FOR DETAILS OF THE RISKS ASSOCIATED WITH THE MAINTENANCE, OPERATION, DECOMMISSIONING AND DEMOLITION PHASES.
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE HEALTH AND SAFETY FILE(S) PRODUCED AND HANDED OVER ON COMPLETION OF THIS PROJECT.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE AS-BUILT DRAWING.
   i. NOTHING SIGNIFICANT OR UNUSUAL

Rev	Date	Description	By	Chk	App
P01	12/06/2015	FOR INFORMATION	MB	AMJ	AKG

FIT FOR INFORMATION

EC HARRIS BUILT ASSET CONSULTANCY
Llywodraeth Cymru Welsh Government
RAMBOLL
Balfour Beatty
JONES BROS CIVIL ENGINEERING UK
PARSONS BRINCKERHOFF
Ty Glyn, Caniol Y Dre, Ruthin Denbighshire Tel: 01824 703661
TACP

Site/Project:

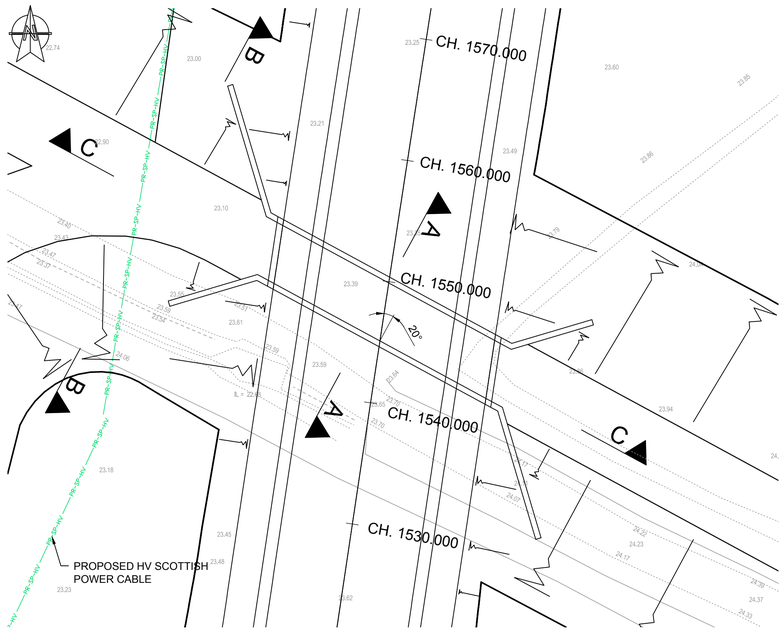
A487 CAERNARFON TO BONTNEWYDD BYPASS

Title:

S103 TY'N LLAN OVERBRIDGE GENERAL ARRANGEMENT (WG No. A487 571)

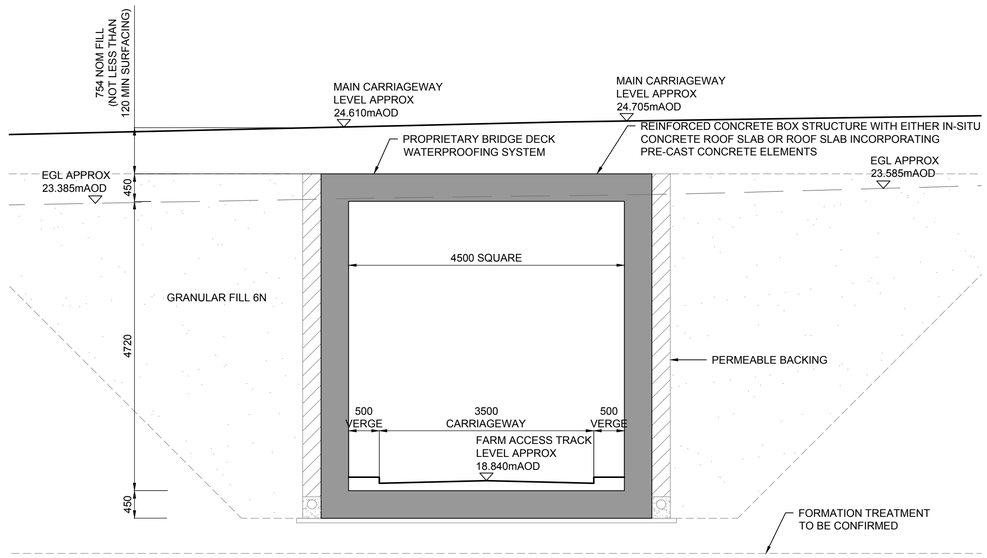
Drawn: M.Barka		Checked: A.Jarman	
Designed: A. GROVES		Approved: A.Groves	
Date: 01/06/15	Scale: AS SHOWN	A1	Sheet:
Container Number:			Revision:
3513874-PB-SBR-103-DR-S-00001			P01

© Copyright Parsons Brinckerhoff

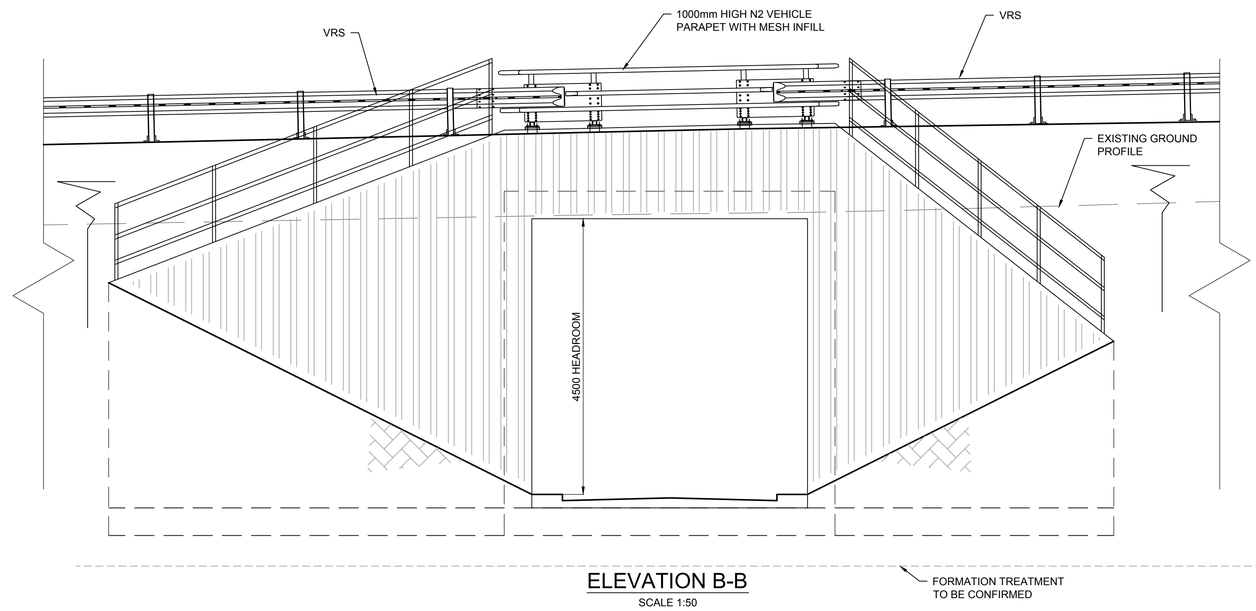


WORK IN CLOSE PROXIMITY TO HV CABLES

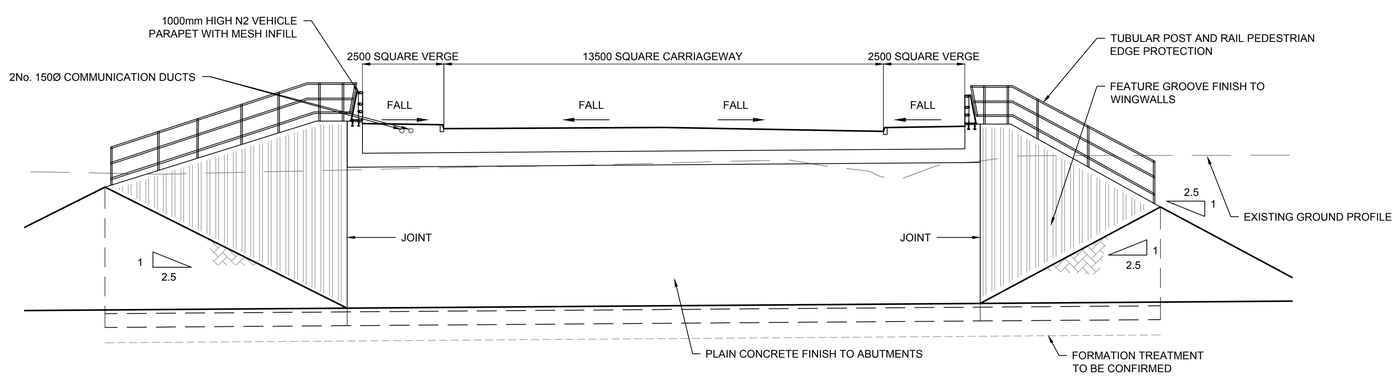
PLAN
SCALE 1:250



SECTION A-A
SCALE 1:50



ELEVATION B-B
SCALE 1:50



ELEVATION C-C
SCALE 1:100

© Crown copyright and database rights 2015
Ordnance Survey 0100031673
© Getmapping plc.

NOTES
A1

1. THIS IS A C.A.D. DRAWING AND SHOULD NOT BE AMENDED BY HAND.
2. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

HEALTH AND SAFETY INFORMATION

SIGNIFICANT OR EXCEPTIONAL RISKS ARE IDENTIFIED BELOW

CONSTRUCTION PHASE

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE WORKS INFORMATION FOR DETAILS OF THE RISKS ASSOCIATED WITH THIS WORK.
2. IN PREPARATION OF CONSTRUCTION METHOD STATEMENTS CONSIDERATION SHOULD BE GIVEN TO THE CLOSE PROXIMITY OF ANY STRUCTURES THAT MAY BE AFFECTED BY CONSTRUCTION.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE DRAWING.
   i. WORK IN CLOSE PROXIMITY TO HV CABLES .
4. THE CONTRACTOR SHALL REFER TO STATUTORY UNDERTAKERS LAYOUT DRAWINGS AND IDENTIFY LOCATIONS OF EXISTING UNDERGROUND SERVICES PRIOR TO CARRYING OUT EXCAVATION WORKS.

MAINTENANCE / OPERATION / DECOMMISSIONING / DEMOLITION PHASES

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE MAINTENANCE AND REPAIR STRATEGY FOR DETAILS OF THE RISKS ASSOCIATED WITH THE MAINTENANCE, OPERATION, DECOMMISSIONING AND DEMOLITION PHASES.
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE HEALTH AND SAFETY FILE(S) PRODUCED AND HANDED OVER ON COMPLETION OF THIS PROJECT.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE AS-BUILT DRAWING.
   i. NOTHING SIGNIFICANT OR UNUSUAL

Rev	Date	Description	By	Chk	App
P01	12/06/2015	FOR INFORMATION	MB	AMJ	AKG

FIT FOR INFORMATION

EC HARRIS BUILT ASSET CONSULTANCY
Llywodraeth Cymru Welsh Government
RAMBOLL
Balfour Beatty
JONES BROS CIVIL ENGINEERING UK
PARSONS BRINCKERHOFF
TACP
Ty Glyn, Caniol Y Dre, Ruthin Denbighshire Tel: 01824 703661

Site/Project:

A487 CAERNARFON TO BONTNEWYDD BYPASS

Title:

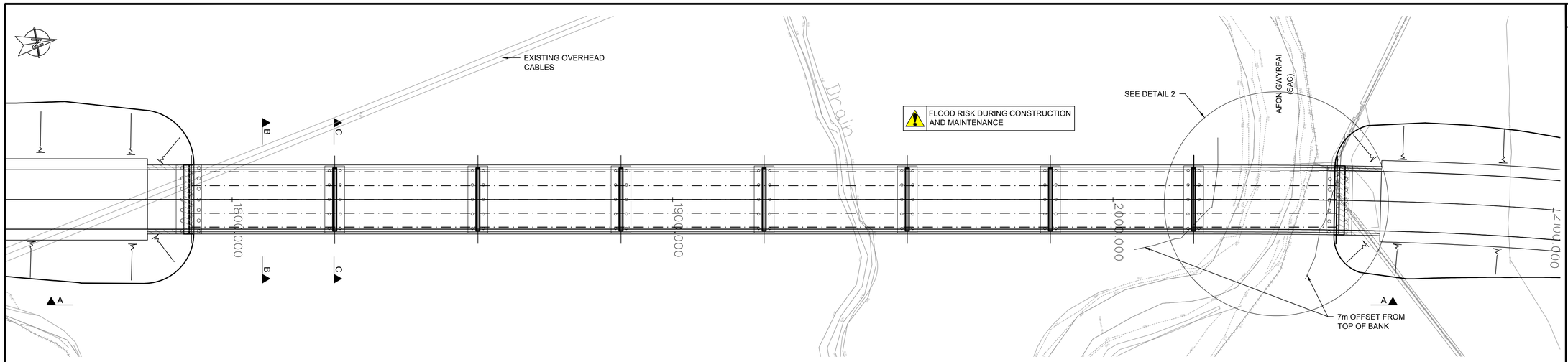
S105 DINAS ACCOMMODATION UNDERPASS
GENERAL ARRANGEMENT
(WG A487 575)

Drawn: M.Barka		Checked: A.Jarman	
Designed: A. GROVES		Approved: A.Groves	
Date: 08/06/15	Scale: AS SHOWN	A1	Sheet:

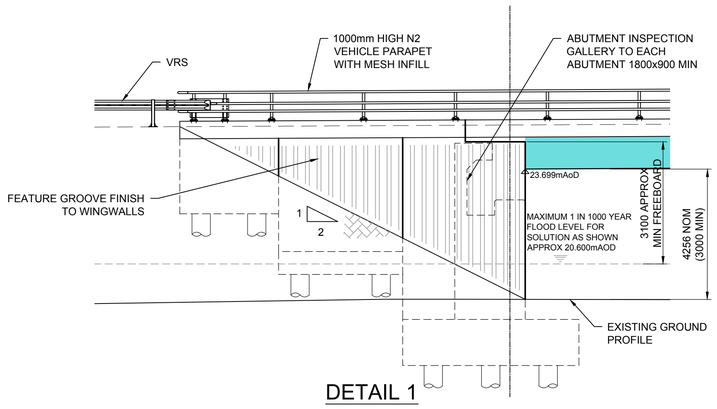
Container Number: 3513874-PB-SBR-105-DR-S-00001

Revision: P01

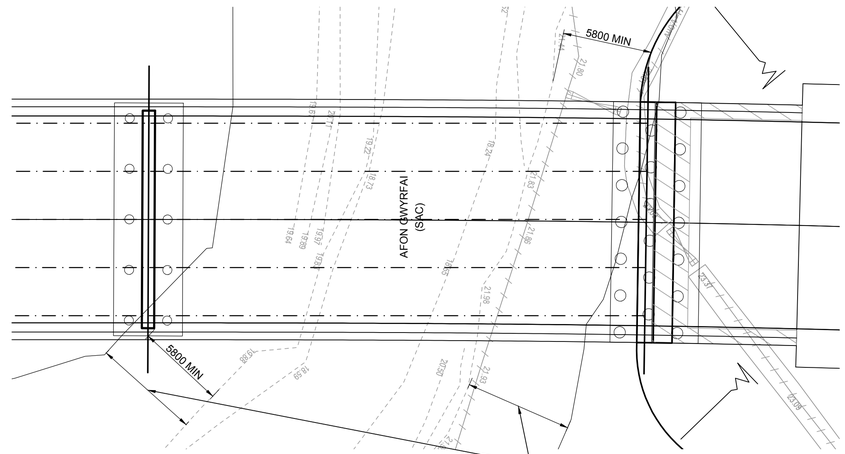
© Copyright Parsons Brinckerhoff



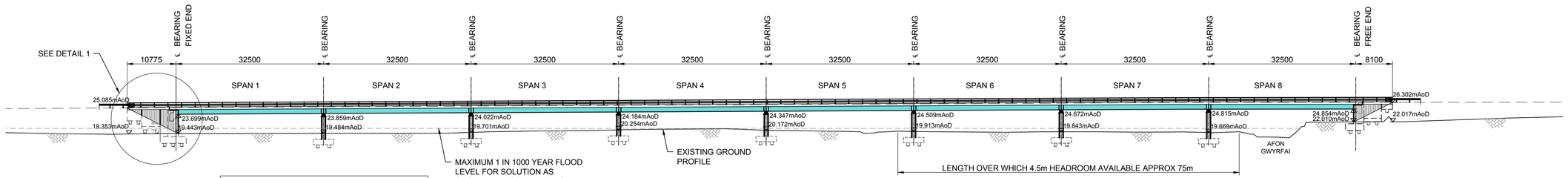
PLAN
SCALE 1:500



DETAIL 1
SCALE 1:100

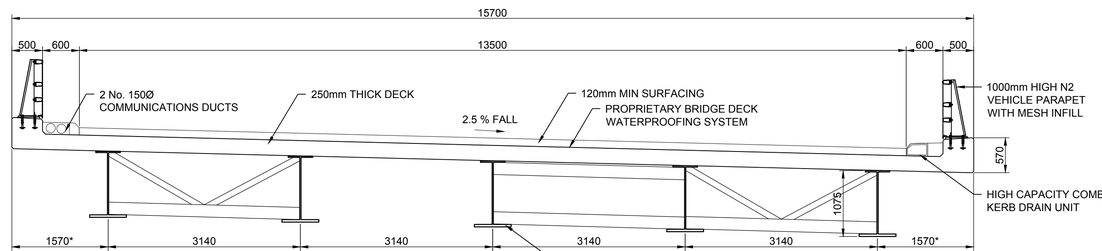


DETAIL 2
SCALE 1:200



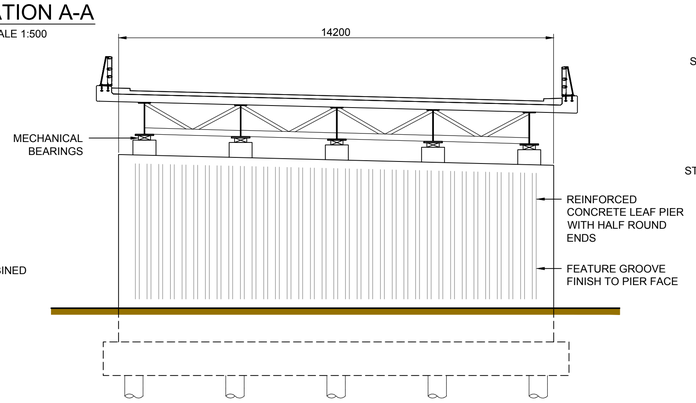
NOTE: PIER FOUNDATIONS INDICATED AS PILED. SUBJECT TO RECEIPT OF GROUND INVESTIGATION DATA AND ASSOCIATED TESTING, SPREAD FOUNDATIONS MAY BE FEASIBLE

ELEVATION A-A
SCALE 1:500

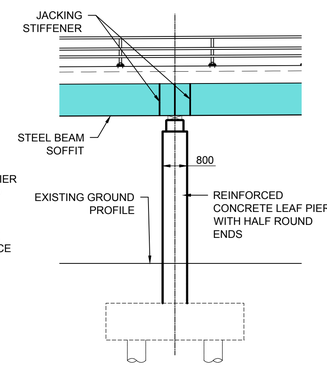


ODD NUMBER OF GIRDERS LEADING TO INSTABILITY DURING ERECTION

SECTION B-B
SCALE 1:50



ELEVATION C-C
SCALE 1:100



TYPICAL PIER END ELEVATION
SCALE 1:100

© Crown copyright and database rights 2015 Ordnance Survey 0100031673
© Getmapping plc.

NOTES

1. THIS IS A C.A.D. DRAWING AND SHOULD NOT BE AMENDED BY HAND.
2. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.
3. THE LEVEL AND HIGHWAY ALIGNMENT INFORMATION ON THIS DRAWING USE THE FOLLOWING MODELS.
   TOPO: 3513874-EXT-XX-XX-M3-Z-00007 VER. A (Topographical survey Ch.2050 to Ch.2950)
   3513874-EXT-XX-XX-M3-Z-00010 VER. A (Topographical survey Ch.840 to Ch.2050)
   HIGHWAY:3513874-PB-XX-XX-M3-J-00006 VER P01.1 (Mainline Proposed strings Design Freeze 14.05.15)
4. THE AFON GWYRFAI IS A SPECIAL AREA OF CONSERVATION BETWEEN RIVER BANKS. CONSTRUCTION RESTRICTION WILL APPLY.

HEALTH AND SAFETY INFORMATION

SIGNIFICANT OR EXCEPTIONAL RISKS ARE IDENTIFIED BELOW

CONSTRUCTION PHASE

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE WORKS INFORMATION FOR DETAILS OF THE RISKS ASSOCIATED WITH THIS WORK.
2. IN PREPARATION OF CONSTRUCTION METHOD STATEMENTS CONSIDERATION SHOULD BE GIVEN TO THE CLOSE PROXIMITY OF ANY STRUCTURES THAT MAY BE AFFECTED BY CONSTRUCTION.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE DRAWING.
   i. ODD NUMBER OF GIRDERS LEADING TO INSTABILITY DURING ERECTION.
   ii. FLOOD RISK DURING CONSTRUCTION AND MAINTENANCE
4. THE CONTRACTOR SHALL REFER TO STATUTORY UNDERTAKERS LAYOUT DRAWINGS AND IDENTIFY LOCATIONS OF EXISTING UNDERGROUND SERVICES PRIOR TO CARRYING OUT EXCAVATION WORKS.

MAINTENANCE / OPERATION / DECOMMISSIONING / DEMOLITION PHASES

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE MAINTENANCE AND REPAIR STRATEGY FOR DETAILS OF THE RISKS ASSOCIATED WITH THE MAINTENANCE, OPERATION, DECOMMISSIONING AND DEMOLITION PHASES.
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE HEALTH AND SAFETY FILE(S) PRODUCED AND HANDED OVER ON COMPLETION OF THIS PROJECT.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE AS-BUILT DRAWING.
   i. NOTHING SIGNIFICANT OR UNUSUAL

Rev	Date	Description	By	Chk	App
P01	12/06/2015	FOR INFORMATION	MB	AMJ	AKG

FIT FOR INFORMATION

EC HARRIS BUILT ASSET CONSULTANCY
Llywodraeth Cymru Welsh Government
RAMBOLL
Balfour Beatty
JONES BROS CIVIL ENGINEERING UK
PARSONS BRINCKERHOFF
Ty Glyn, Canol Y Dre, Ruthin Denbighshire Tel: 01824 703661
TACP

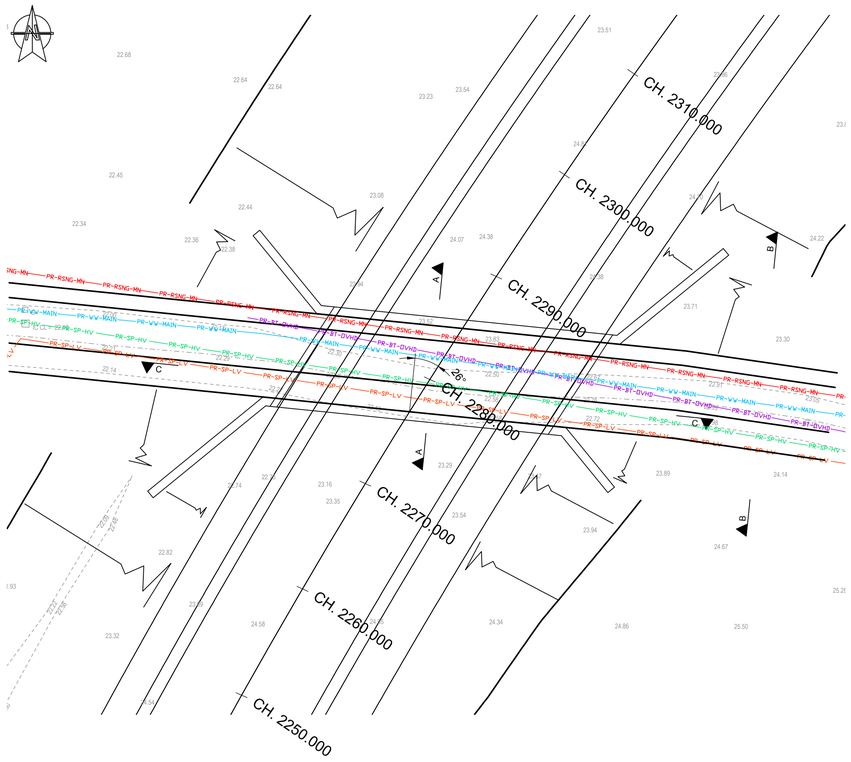
Site/Project:
A487 CAERNARFON TO BONTNEWYDD BYPASS

Title:
S106 AFON GWYRFAI VIADUCT GENERAL ARRANGEMENT (WG A487 581)

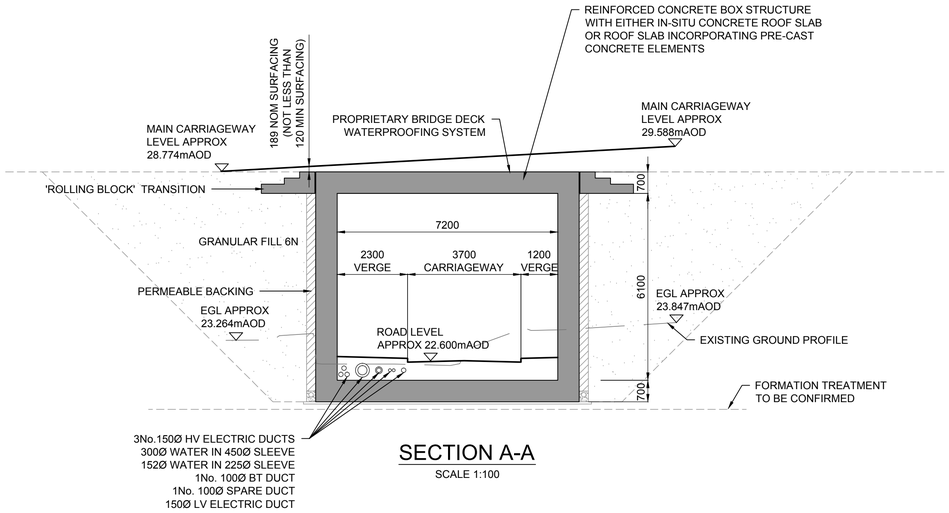
Drawn: M.Barka		Checked: A.Jarman	
Designed: A. GROVES		Approved: A.Groves	
Date: 29/04/15	Scale: AS SHOWN	A1	Sheet:

Container Number: 3513874-PB-SBR-106-DR-S-00001
Revision: P01

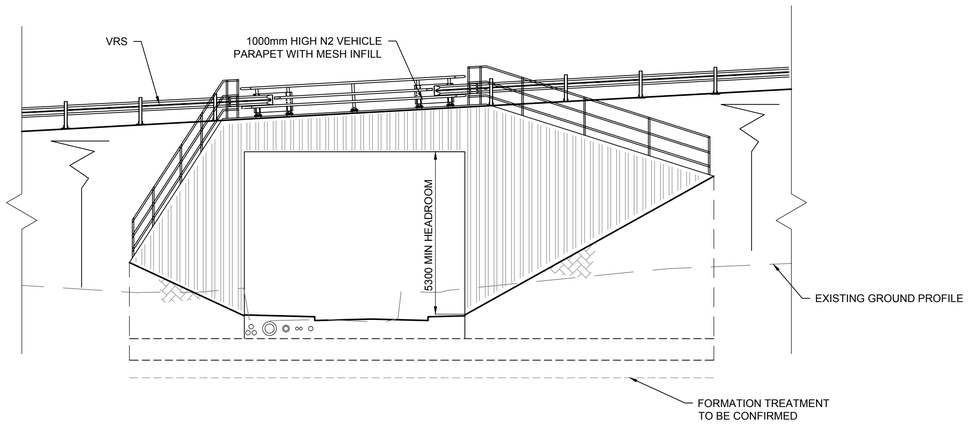
© Copyright Parsons Brinckerhoff



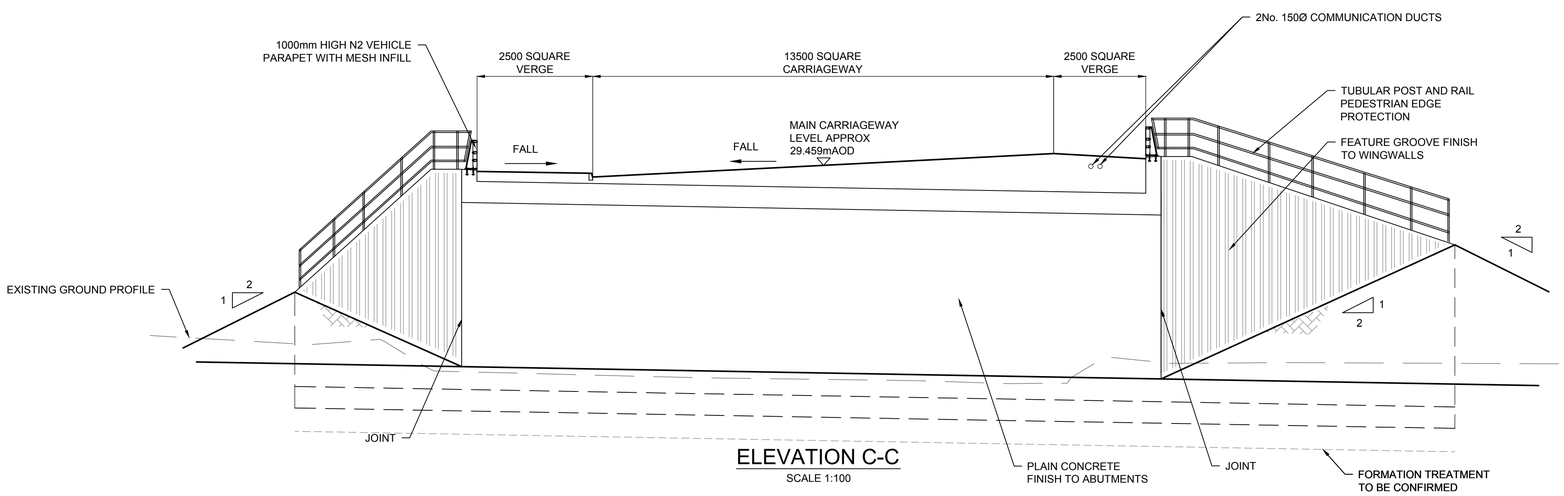
PLAN
SCALE 1:250



SECTION A-A
SCALE 1:100



ELEVATION B-B
SCALE 1:100



ELEVATION C-C
SCALE 1:100

© Crown copyright and database rights 2015
Ordnance Survey 0100031673
© Getmapping plc.

NOTES

1. THIS IS A C.A.D. DRAWING AND SHOULD NOT BE AMENDED BY HAND.
2. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

HEALTH AND SAFETY INFORMATION

SIGNIFICANT OR EXCEPTIONAL RISKS ARE IDENTIFIED BELOW

CONSTRUCTION PHASE

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE WORKS INFORMATION FOR DETAILS OF THE RISKS ASSOCIATED WITH THIS WORK.
2. IN PREPARATION OF CONSTRUCTION METHOD STATEMENTS CONSIDERATION SHOULD BE GIVEN TO THE CLOSE PROXIMITY OF ANY STRUCTURES THAT MAY BE AFFECTED BY CONSTRUCTION.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE DRAWING.
   i. NOTHING SIGNIFICANT OR UNUSUAL.
4. THE CONTRACTOR SHALL REFER TO STATUTORY UNDERTAKERS LAYOUT DRAWINGS AND IDENTIFY LOCATIONS OF EXISTING UNDERGROUND SERVICES PRIOR TO CARRYING OUT EXCAVATION WORKS.

MAINTENANCE / OPERATION / DECOMMISSIONING / DEMOLITION PHASES

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE MAINTENANCE AND REPAIR STRATEGY FOR DETAILS OF THE RISKS ASSOCIATED WITH THE MAINTENANCE, OPERATION, DECOMMISSIONING AND DEMOLITION PHASES.
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE HEALTH AND SAFETY FILE(S) PRODUCED AND HANDED OVER ON COMPLETION OF THIS PROJECT.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE AS-BUILT DRAWING.
   i. NOTHING SIGNIFICANT OR UNUSUAL.

Rev	Date	Description	By	Chk	App
P01	12/06/2015	FOR INFORMATION	MB	AMJ	AKG

FIT FOR INFORMATION

EC HARRIS BUILT ASSET CONSULTANCY
Llywodraeth Cymru Welsh Government
RAMBOLL
Balfour Beatty
JONES BROS CIVIL ENGINEERING UK
PARSONS BRINCKERHOFF
TACP
Ty Glyn, Canol Y Dre, Ruthin Denbighshire Tel: 01824 703661

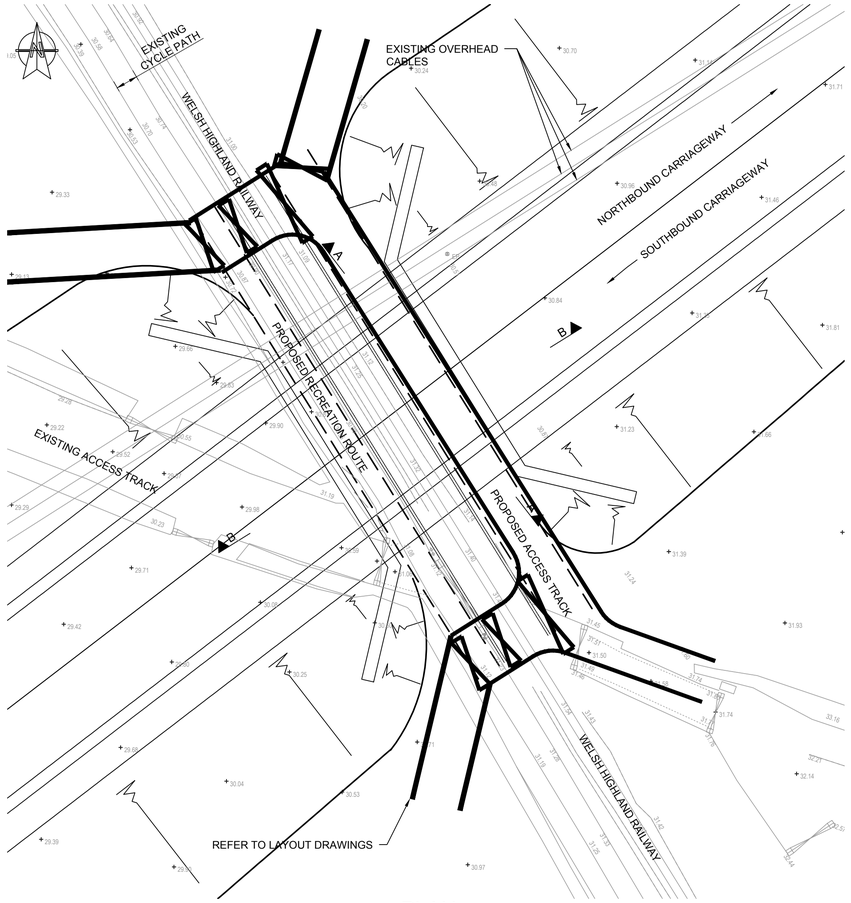
Site/Project:
A487 CAERNARFON TO BONTNEWYDD BYPASS

Title:
S107 PONT LLYDIART GWYN GENERAL ARRANGEMENT (WG No. A487 585)

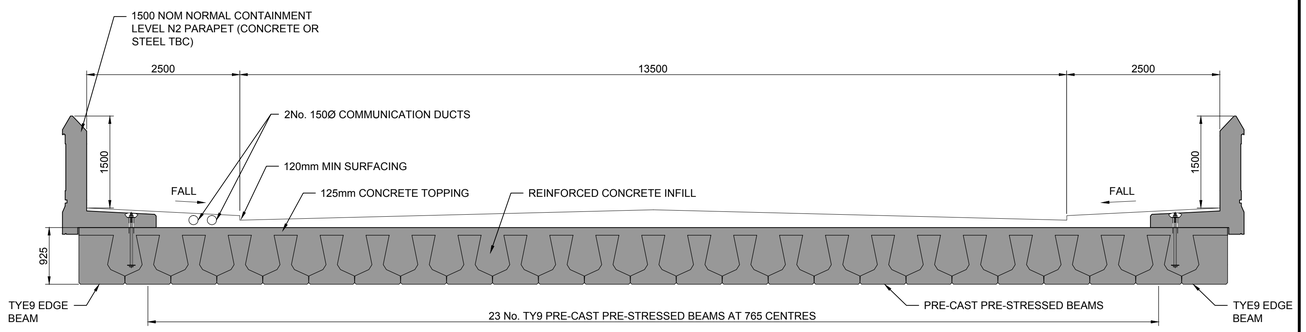
Drawn: M.Barka		Checked: A.Jarman	
Designed: A. GROVES		Approved: A.Groves	
Date: 11/06/15	Scale: AS SHOWN	A1	Sheet:

Container Number: 3513874-PB-SBR-107-DR-S-00001
Revision: P01

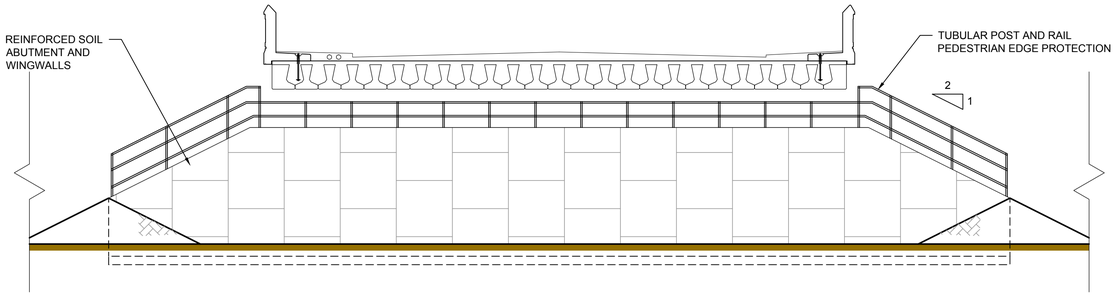
© Copyright Parsons Brinckerhoff



PLAN
SCALE 1:250

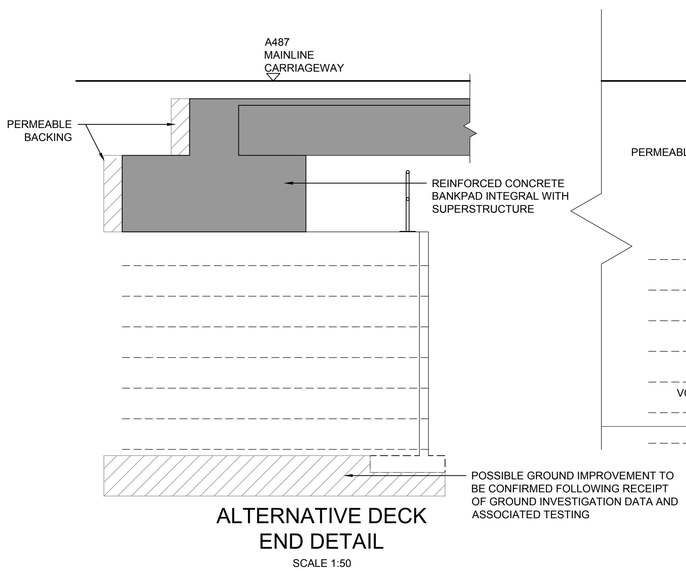


SECTION A-A
SCALE 1:50

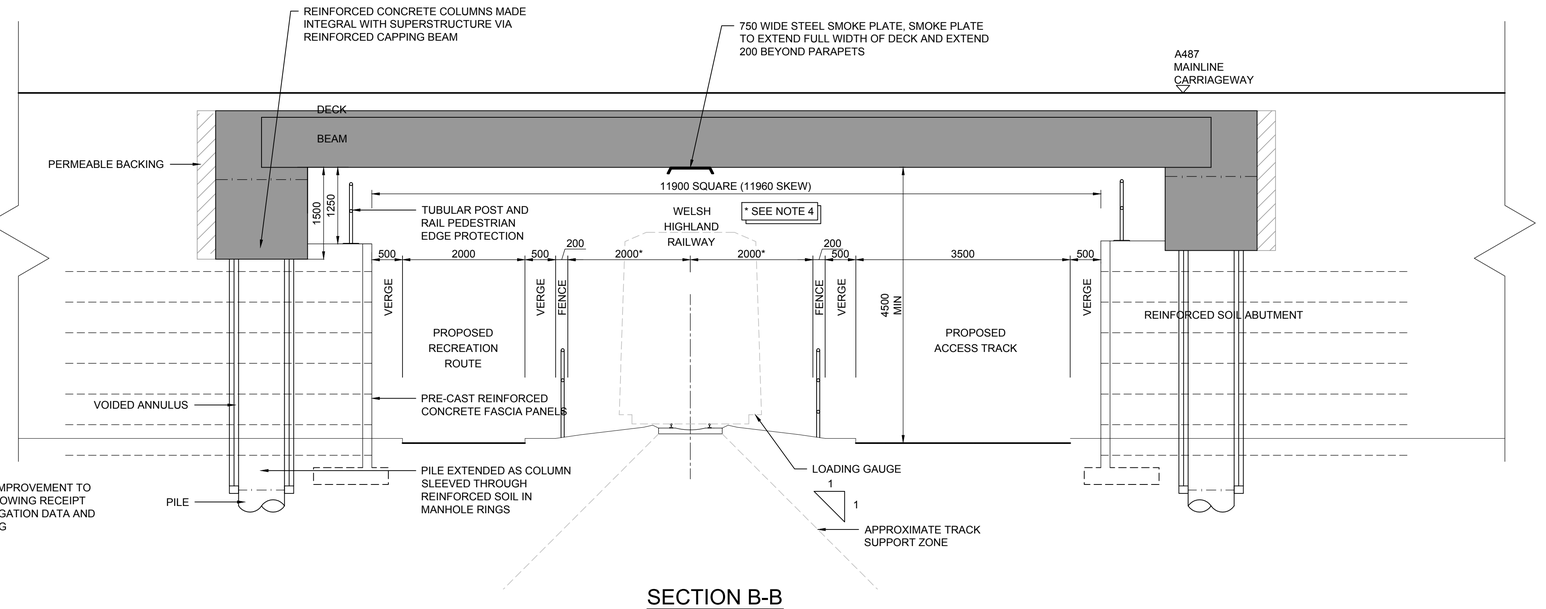


ELEVATION ON ABUTMENT
SCALE 1:100

WORKING IN CLOSE PROXIMITY TO AND AT HEIGHT TO LIVE HERITAGE RAILWAY



ALTERNATIVE DECK END DETAIL
SCALE 1:50



SECTION B-B
SCALE 1:50

© Crown copyright and database rights 2015
Ordnance Survey 0100031673
© Getmapping plc.

NOTES
A1

1. THIS IS A C.A.D. DRAWING AND SHOULD NOT BE AMENDED BY HAND.
2. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.
3. FARM ACCESS WIDTH BASED ON DIMENSIONS SHOWN IN FIGURE 1 OF REPORT ON THE STUDY ON DIMENSIONS OF AGRICULTURAL BRIDGES AND UNDERPASSES.
4. OFFSETS FROM RAILWAY CENTERLINE TAKEN FROM WELSH HIGHLAND RAIL LOAD AND STRUCTURE GAUGE DRG. PW30A WITH 2000 = DIM B = DISTANCE TO STRUCTURES AND FENCE LINES.

HEALTH AND SAFETY INFORMATION

SIGNIFICANT OR EXCEPTIONAL RISKS ARE IDENTIFIED BELOW

CONSTRUCTION PHASE

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE WORKS INFORMATION FOR DETAILS OF THE RISKS ASSOCIATED WITH THIS WORK.
2. IN PREPARATION OF CONSTRUCTION METHOD STATEMENTS CONSIDERATION SHOULD BE GIVEN TO THE CLOSE PROXIMITY OF ANY STRUCTURES THAT MAY BE AFFECTED BY CONSTRUCTION.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE DRAWING.
   i. WORKING IN CLOSE PROXIMITY TO AND AT HEIGHT TO LIVE HERITAGE RAILWAY .
4. THE CONTRACTOR SHALL REFER TO STATUTORY UNDERTAKERS LAYOUT DRAWINGS AND IDENTIFY LOCATIONS OF EXISTING UNDERGROUND SERVICES PRIOR TO CARRYING OUT EXCAVATION WORKS.

MAINTENANCE / OPERATION / DECOMMISSIONING / DEMOLITION PHASES

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE MAINTENANCE AND REPAIR STRATEGY FOR DETAILS OF THE RISKS ASSOCIATED WITH THE MAINTENANCE, OPERATION, DECOMMISSIONING AND DEMOLITION PHASES.
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE HEALTH AND SAFETY FILE(S) PRODUCED AND HANDED OVER ON COMPLETION OF THIS PROJECT.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE AS-BUILT DRAWING.
   i. NOTHING SIGNIFICANT OR UNUSUAL

Rev	Date	Description	By	Chk	App
P01.1	09/06/2015	DRAFT	MB		

FIT FOR INFORMATION

EC HARRIS BUILT ASSET CONSULTANCY
Llywodraeth Cymru Welsh Government
Balfour Beatty JONES BROS CIVIL ENGINEERING UK
PARSONS BRINCKERHOFF
TACP
Ty Glyn, Canol Y Dre, Ruthin Denbighshire Tel: 01824 703661

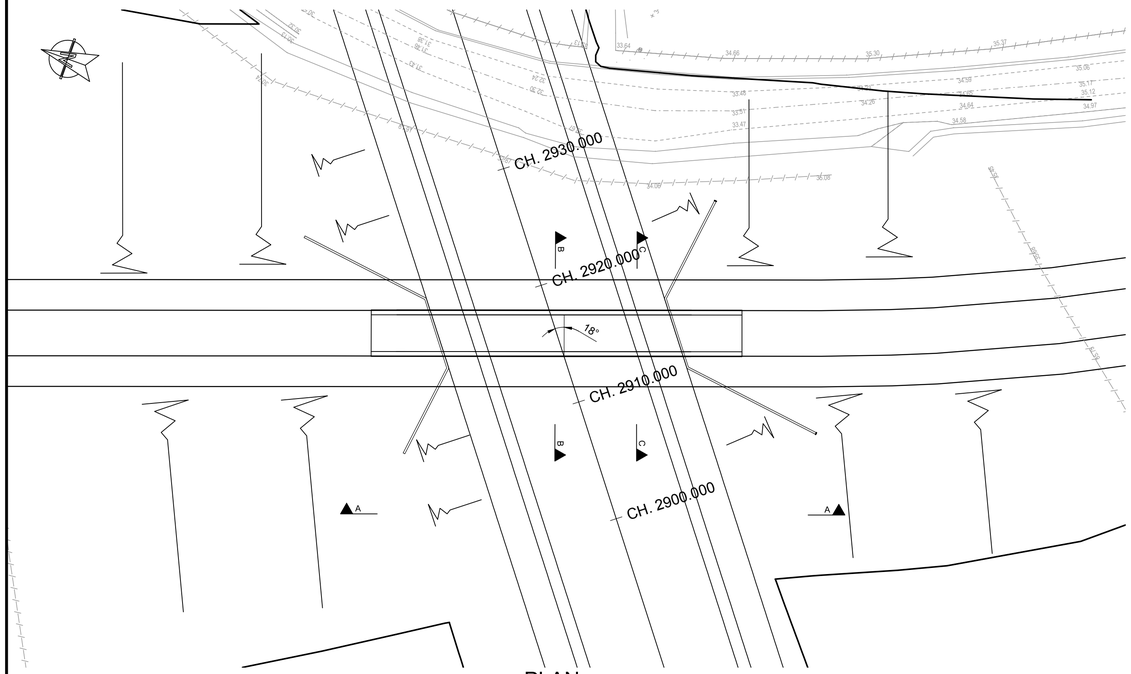
Site/Project:
A487 CAERNARFON TO BONTNEWYDD BYPASS

Title:
S108 PONT CEFNWERTHYD GENERAL ARRANGEMENT (WG No. A487 591)

Drawn: M.Barka		Checked: A.Jarman	
Designed: A. GROVES		Approved: A.Groves	
Date: 09/06/15	Scale: AS SHOWN	A1	Sheet:

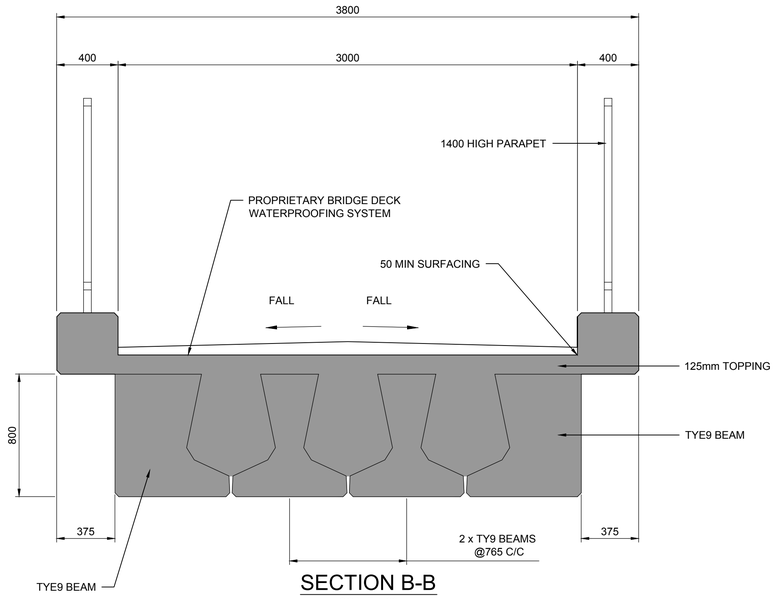
Container Number: 3513874-PB-SBR-108-DR-S-00001
Revision: P01

© Copyright Parsons Brinckerhoff



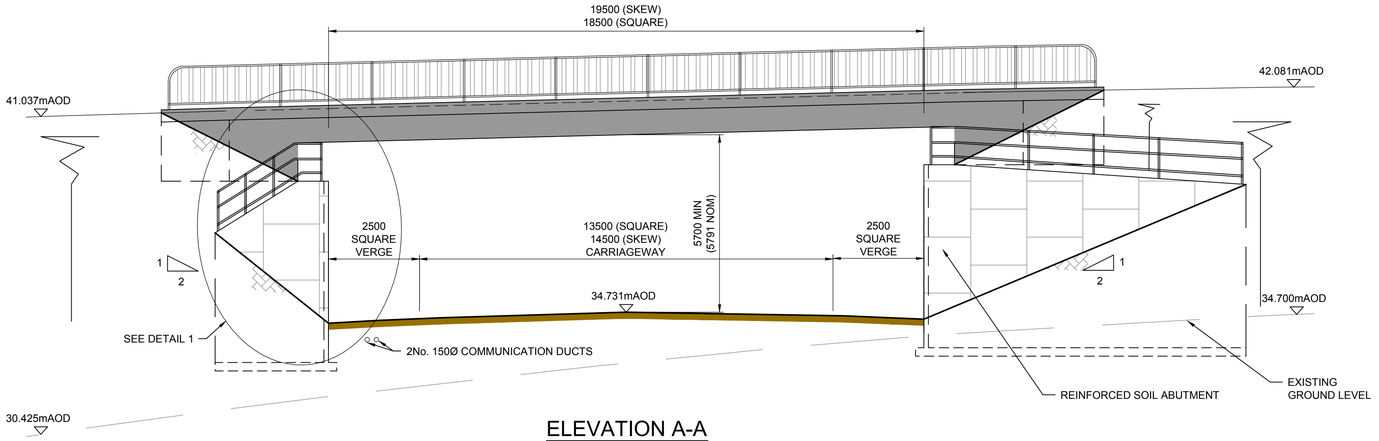
PLAN

SCALE 1:250



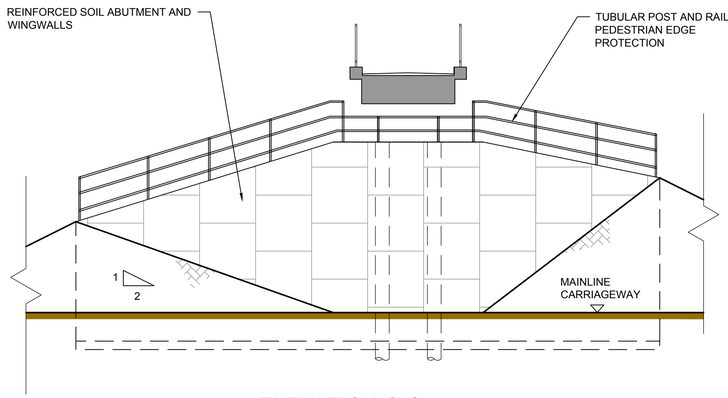
SECTION B-B

SCALE 1:20



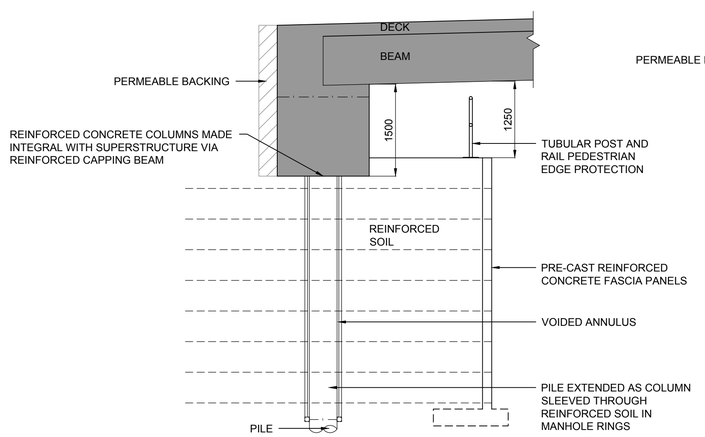
ELEVATION A-A

SCALE 1:100



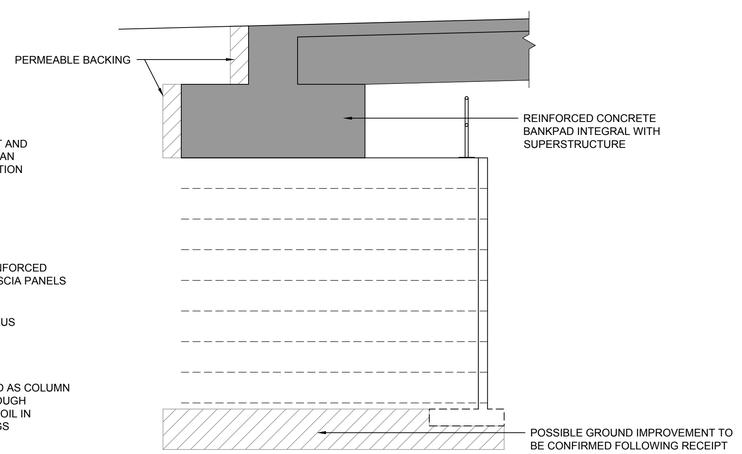
ELEVATION C-C

SCALE 1:100



DETAIL 1

SCALE 1:50



ALTERNATIVE DETAIL 1

SCALE 1:50

© Crown copyright and database rights 2015 Ordnance Survey 0100031673
© Getmapping plc.

NOTES

A1

1. THIS IS A C.A.D. DRAWING AND SHOULD NOT BE AMENDED BY HAND.
2. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

HEALTH AND SAFETY INFORMATION

SIGNIFICANT OR EXCEPTIONAL RISKS ARE IDENTIFIED BELOW

CONSTRUCTION PHASE

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE WORKS INFORMATION FOR DETAILS OF THE RISKS ASSOCIATED WITH THIS WORK.
2. IN PREPARATION OF CONSTRUCTION METHOD STATEMENTS CONSIDERATION SHOULD BE GIVEN TO THE CLOSE PROXIMITY OF ANY STRUCTURES THAT MAY BE AFFECTED BY CONSTRUCTION.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE DRAWING.
   i. NOTHING SIGNIFICANT OR UNUSUAL.
4. THE CONTRACTOR SHALL REFER TO STATUTORY UNDERTAKERS LAYOUT DRAWINGS AND IDENTIFY LOCATIONS OF EXISTING UNDERGROUND SERVICES PRIOR TO CARRYING OUT EXCAVATION WORKS.

MAINTENANCE / OPERATION / DECOMMISSIONING / DEMOLITION PHASES

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE MAINTENANCE AND REPAIR STRATEGY FOR DETAILS OF THE RISKS ASSOCIATED WITH THE MAINTENANCE, OPERATION, DECOMMISSIONING AND DEMOLITION PHASES.
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE HEALTH AND SAFETY FILE(S) PRODUCED AND HANDED OVER ON COMPLETION OF THIS PROJECT.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE AS-BUILT DRAWING.
   i. NOTHING SIGNIFICANT OR UNUSUAL

Rev	Date	Description	By	Chk	App
P01	17/06/2015	FOR INFORMATION	MB	AMJ	AKG

FIT FOR INFORMATION

EC HARRIS BUILT ASSET CONSULTANCY
Llywodraeth Cymru Welsh Government
RAMBOLL
Balfour Beatty
JONES BROS CIVIL ENGINEERING UK
PARSONS BRINCKERHOFF
Ty Glyn, Caroll Y Dre, Ruthin Denbighshire Tel: 01824 703661
TACP

Site/Project:

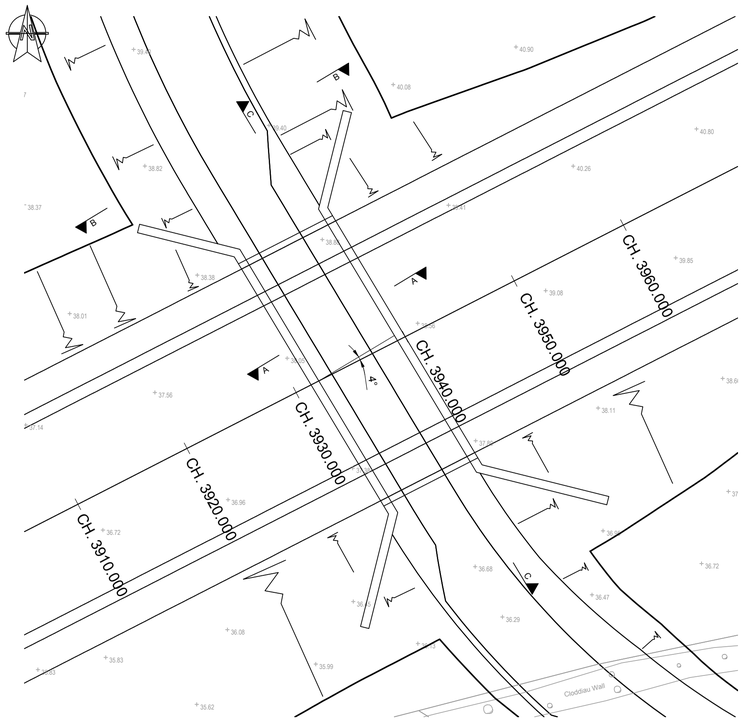
A487 CAERNARFON TO BONTNEWYDD BYPASS

Title:

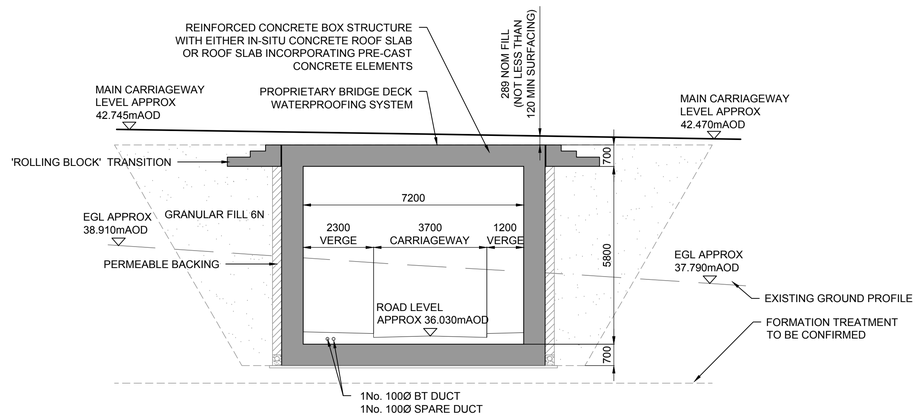
S109 PONT CERIW NMU OVERBRIDGE GENERAL ARRANGEMENT (WG No. A487 601)

Drawn: M.Barka		Checked: A.Jarman	
Designed: A. GROVES		Approved: A.Groves	
Date: 12/06/15	Scale: AS SHOWN @ A1	Sheet:	
Container Number:			Revision:
3513874-PB-SBR-109-DR-S-00001			P01

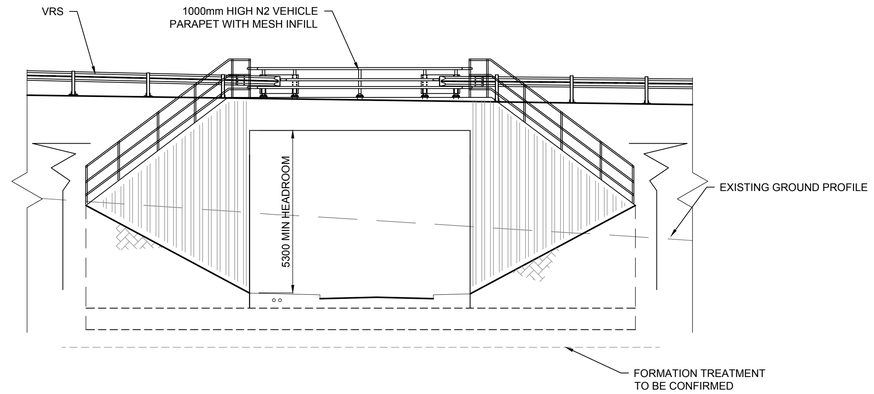
© Copyright Parsons Brinckerhoff



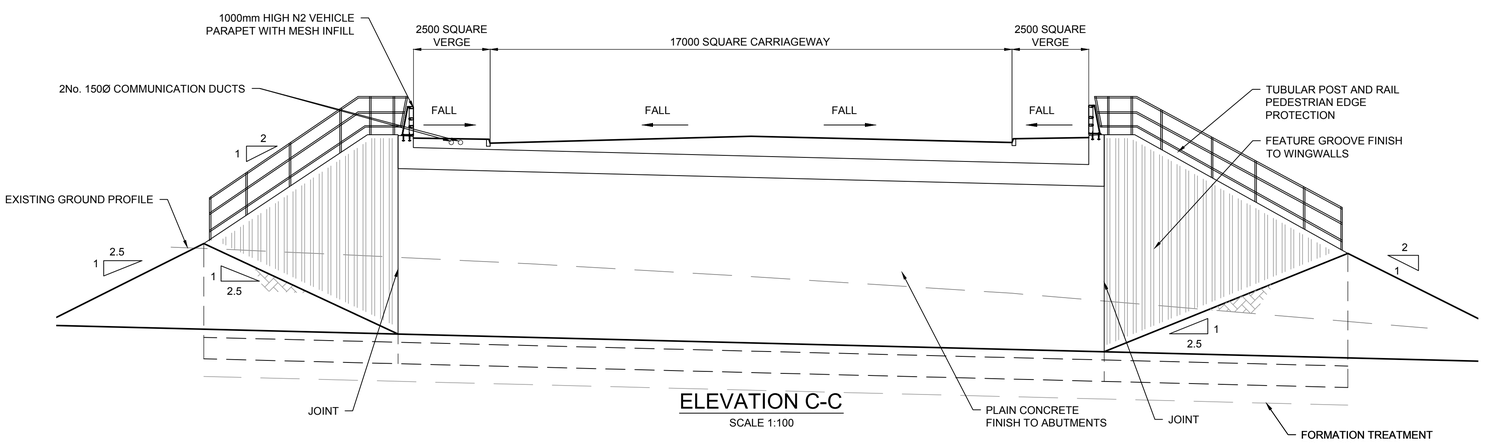
PLAN
SCALE 1:250



SECTION A-A
SCALE 1:100



ELEVATION B-B
SCALE 1:100



ELEVATION C-C
SCALE 1:100

© Crown copyright and database rights 2015
Ordnance Survey 0100031673
© Getmapping plc.

NOTES

1. THIS IS A C.A.D. DRAWING AND SHOULD NOT BE AMENDED BY HAND.
2. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

HEALTH AND SAFETY INFORMATION

SIGNIFICANT OR EXCEPTIONAL RISKS ARE IDENTIFIED BELOW

CONSTRUCTION PHASE

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE WORKS INFORMATION FOR DETAILS OF THE RISKS ASSOCIATED WITH THIS WORK.
2. IN PREPARATION OF CONSTRUCTION METHOD STATEMENTS CONSIDERATION SHOULD BE GIVEN TO THE CLOSE PROXIMITY OF ANY STRUCTURES THAT MAY BE AFFECTED BY CONSTRUCTION.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE DRAWING.
   i. NOTHING SIGNIFICANT OR UNUSUAL.
4. THE CONTRACTOR SHALL REFER TO STATUTORY UNDERTAKERS LAYOUT DRAWINGS AND IDENTIFY LOCATIONS OF EXISTING UNDERGROUND SERVICES PRIOR TO CARRYING OUT EXCAVATION WORKS.

MAINTENANCE / OPERATION / DECOMMISSIONING / DEMOLITION PHASES

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE MAINTENANCE AND REPAIR STRATEGY FOR DETAILS OF THE RISKS ASSOCIATED WITH THE MAINTENANCE, OPERATION, DECOMMISSIONING AND DEMOLITION PHASES.
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE HEALTH AND SAFETY FILE(S) PRODUCED AND HANDED OVER ON COMPLETION OF THIS PROJECT.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE AS-BUILT DRAWING.
   i. NOTHING SIGNIFICANT OR UNUSUAL

Rev	Date	Description	By	Chk	App
P01	12/06/2015	FOR INFORMATION	MB	AMJ	AKG

FIT FOR INFORMATION

EC HARRIS BUILT ASSET CONSULTANCY
Llywodraeth Cymru Welsh Government
RAMBOLL
Balfour Beatty
JONES BROS CIVIL ENGINEERING UK
PARSONS BRINCKERHOFF
TACP
Ty Glyn, Canol Y Dre, Ruthin Denbighshire Tel: 01824 703661

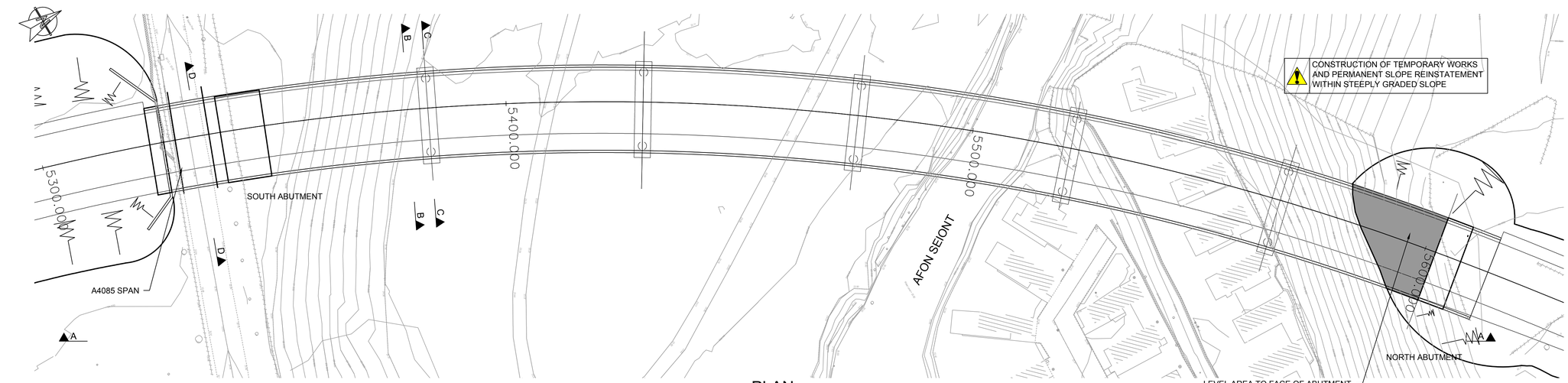
Site/Project:
A487 CAERNARFON TO BONTNEWYDD BYPASS

Title:
S111 PONT BRYN MAFON GENERAL ARRANGEMENT (WG No. A487 611)

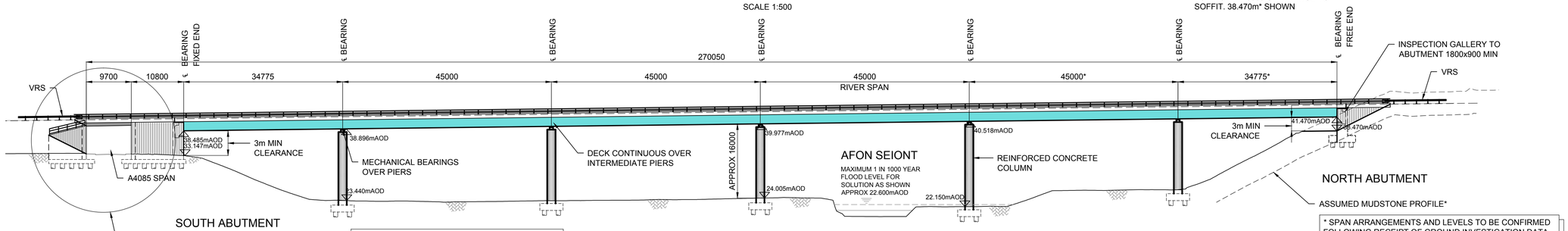
Drawn: M.Barka		Checked: A.Jarman	
Designed: A. GROVES		Approved: A.Groves	
Date: 04/06/15	Scale: AS SHOWN	A1	Sheet:

Container Number: 3513874-PB-SBR-111-DR-S-00001
Revision: P01

© Copyright Parsons Brinckerhoff



PLAN
SCALE 1:500

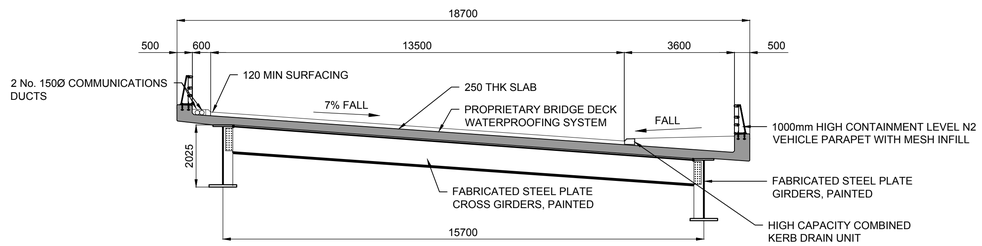


EAST ELEVATION A-A
SCALE 1:500

NOTE: PIER FOUNDATIONS INDICATED AS PILED. SUBJECT TO RECEIPT OF GROUND INVESTIGATION DATA AND ASSOCIATED TESTING, SPREAD FOUNDATIONS MAY BE FEASIBLE

* SPAN ARRANGEMENTS AND LEVELS TO BE CONFIRMED FOLLOWING RECEIPT OF GROUND INVESTIGATION DATA AND ASSOCIATED TESTING RESULTS

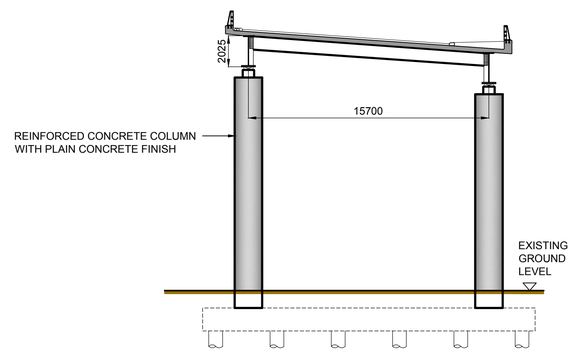
WORKING AT SIGNIFICANT HEIGHT AND OVER WATER



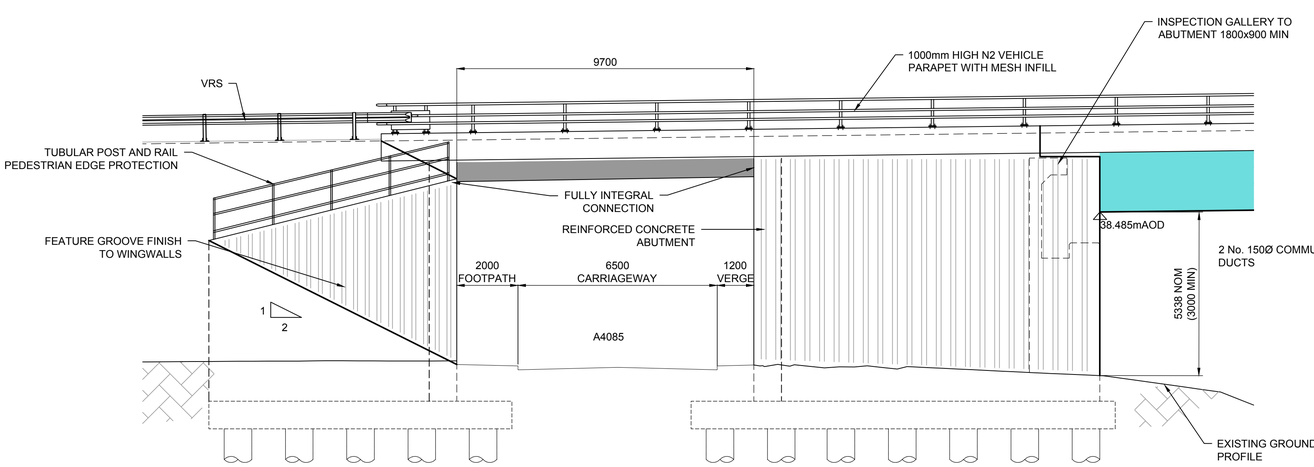
SECTION B-B
SCALE 1:100

GIRDER INSTABILITY DURING ERECTION IF ERECTED SINGLY

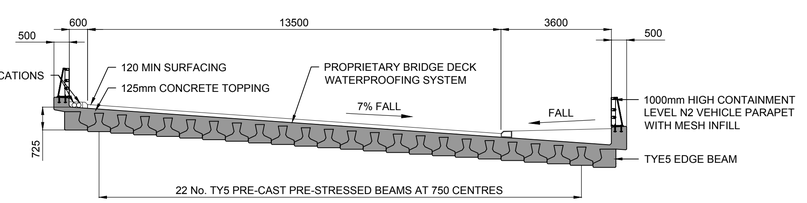
LAYING OF BITUMINOUS SURFACING ON DECK WITH STEEP CROSSFALLS - TRUCK INSTABILITY WHEN RAISED



SECTION C-C
SCALE 1:200



DETAIL A
SCALE 1:100



SECTION D-D
SCALE 1:100

© Crown copyright and database rights 2015 Ordnance Survey 0100031673
© Getmapping plc.

NOTES

1. THIS IS A C.A.D. DRAWING AND SHOULD NOT BE AMENDED BY HAND.
2. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.
3. THE LEVEL AND HIGHWAY ALIGNMENT INFORMATION ON THIS DRAWING USE THE FOLLOWING MODELS.
   TOPO: 3513874-EXT-XX-XX-M3-Z-00002 VER. A
   (Topographical survey Ch.5200 to Ch.6150)
   HIGHWAY:3513874-PB-XX-XX-M3-J-00006 VER P01.1
   (Mainline Proposed strings Design Freeze 14.05.15)

HEALTH AND SAFETY INFORMATION

SIGNIFICANT OR EXCEPTIONAL RISKS ARE IDENTIFIED BELOW

CONSTRUCTION PHASE

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE WORKS INFORMATION FOR DETAILS OF THE RISKS ASSOCIATED WITH THIS WORK.
2. IN PREPARATION OF CONSTRUCTION METHOD STATEMENTS CONSIDERATION SHOULD BE GIVEN TO THE CLOSE PROXIMITY OF ANY STRUCTURES THAT MAY BE AFFECTED BY CONSTRUCTION.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE DRAWING.
   i. GIRDER INSTABILITY DURING ERECTION IF ERECTED SINGLY
   ii. LAYING OF BITUMINOUS SURFACING ON DECK WITH STEEP CROSSFALLS - TRUCK INSTABILITY WHEN RAISED
   iii. WORKING AT SIGNIFICANT HEIGHT AND OVER WATER
   iv. CONSTRUCTION OF TEMPORARY WORKS AND PERMANENT SLOPE REINSTATEMENT WITHIN STEEPLY GRADED SLOPE
4. THE CONTRACTOR SHALL REFER TO STATUTORY UNDERTAKERS LAYOUT DRAWINGS AND IDENTIFY LOCATIONS OF EXISTING UNDERGROUND SERVICES PRIOR TO CARRYING OUT EXCAVATION WORKS.

MAINTENANCE / OPERATION / DECOMMISSIONING / DEMOLITION PHASES

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE MAINTENANCE AND REPAIR STRATEGY FOR DETAILS OF THE RISKS ASSOCIATED WITH THE MAINTENANCE, OPERATION, DECOMMISSIONING AND DEMOLITION PHASES.
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE HEALTH AND SAFETY FILE(S) PRODUCED AND HANDED OVER ON COMPLETION OF THIS PROJECT.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE AS-BUILT DRAWING.
   I. NOTHING SIGNIFICANT OR UNUSUAL.

Rev	Date	Description	By	Chk	App
P01	12/06/2015	FOR INFORMATION	MB	AMJ	AKG

FIT FOR INFORMATION

EC HARRIS BUILT ASSET CONSULTANCY
Llywodraeth Cymru Welsh Government
RAMBOLL
Balfour Beatty
JONES BROS CIVIL ENGINEERING UK
PARSONS BRINCKERHOFF
TACP
Ty Glyn, Caniol Y Dre, Ruthin Denbighshire Tel: 01824 703661

Site/Project:

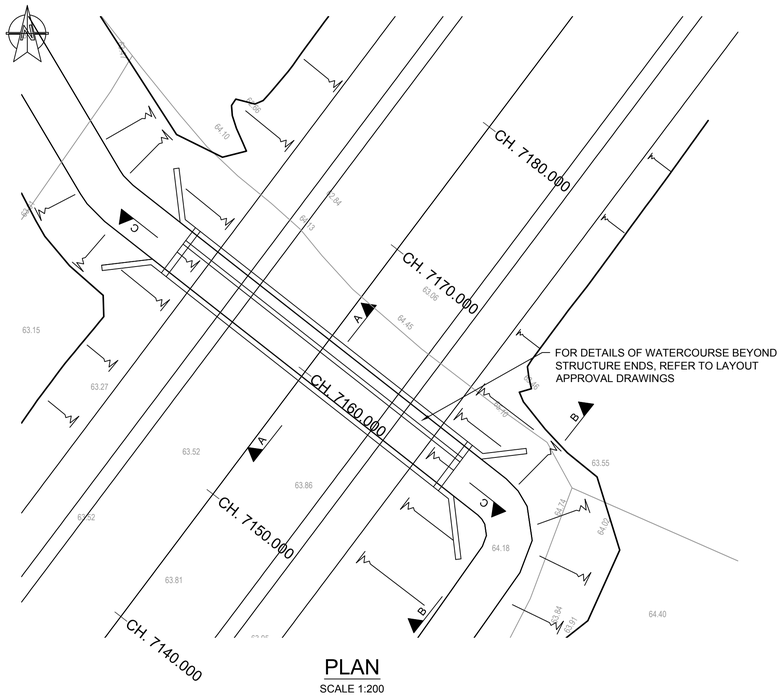
A487 CAERNARFON TO BONTNEWYDD BYPASS

Title:

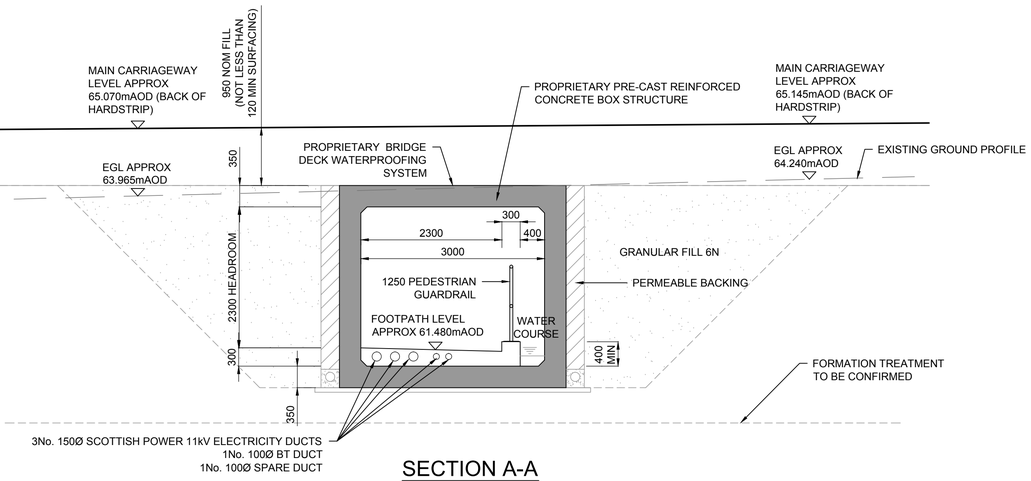
S112 PONT AFON SEIONT NEWYDD VIADUCT GENERAL ARRANGEMENT (WG A487 621)

Drawn: M.Barka		Checked: A.Jarman	
Designed: A. GROVES		Approved: A.Groves	
Date: 27/05/15	Scale: AS SHOWN A1	Sheet:	
Container Number:			Revision:
3513874-PB-SBR-112-DR-S-00001			P01

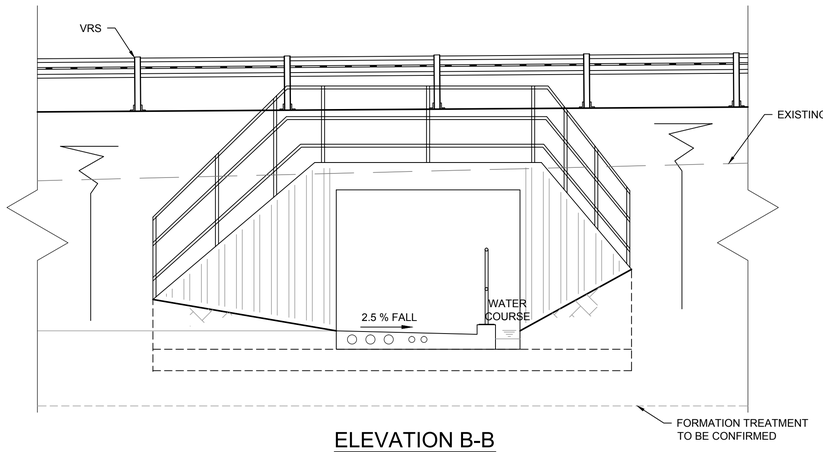
© Copyright Parsons Brinckerhoff



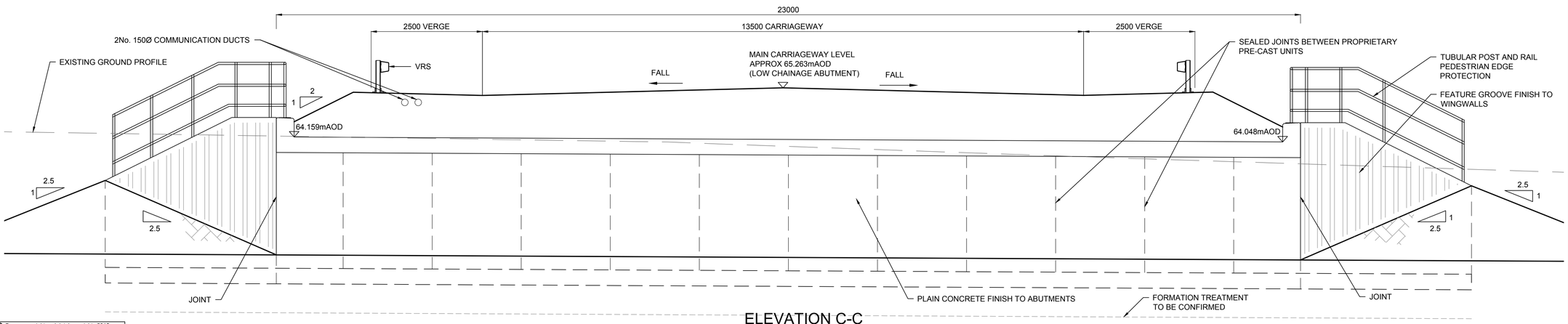
PLAN
SCALE 1:200



SECTION A-A
SCALE 1:50



ELEVATION B-B
SCALE 1:50



ELEVATION C-C
SCALE 1:50

© Crown copyright and database rights 2015
Ordnance Survey 0100031673
© Getmapping plc.

NOTES

A1

1. THIS IS A C.A.D. DRAWING AND SHOULD NOT BE AMENDED BY HAND.
2. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

HEALTH AND SAFETY INFORMATION

SIGNIFICANT OR EXCEPTIONAL RISKS ARE IDENTIFIED BELOW

CONSTRUCTION PHASE

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE WORKS INFORMATION FOR DETAILS OF THE RISKS ASSOCIATED WITH THIS WORK.
2. IN PREPARATION OF CONSTRUCTION METHOD STATEMENTS CONSIDERATION SHOULD BE GIVEN TO THE CLOSE PROXIMITY OF ANY STRUCTURES THAT MAY BE AFFECTED BY CONSTRUCTION.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE DRAWING.
   i. NOTHING SIGNIFICANT OR UNUSUAL.
4. THE CONTRACTOR SHALL REFER TO STATUTORY UNDERTAKERS LAYOUT DRAWINGS AND IDENTIFY LOCATIONS OF EXISTING UNDERGROUND SERVICES PRIOR TO CARRYING OUT EXCAVATION WORKS.

MAINTENANCE / OPERATION / DECOMMISSIONING / DEMOLITION PHASES

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE MAINTENANCE AND REPAIR STRATEGY FOR DETAILS OF THE RISKS ASSOCIATED WITH THE MAINTENANCE, OPERATION, DECOMMISSIONING AND DEMOLITION PHASES.
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE HEALTH AND SAFETY FILE(S) PRODUCED AND HANDED OVER ON COMPLETION OF THIS PROJECT.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE AS-BUILT DRAWING.
   i. NOTHING SIGNIFICANT OR UNUSUAL

Rev	Date	Description	By	Chk	App
P01	12/06/2015	FOR INFORMATION	MB	AMJ	AKG

FIT FOR INFORMATION

EC HARRIS BUILT ASSET CONSULTANCY
Llywodraeth Cymru Welsh Government
RAMBOLL
Balfour Beatty
JONES BROS CIVIL ENGINEERING UK
PARSONS BRINCKERHOFF
TACP
Ty Glyn, Canol Y Dre, Ruthin Denbighshire Tel: 01824 703661

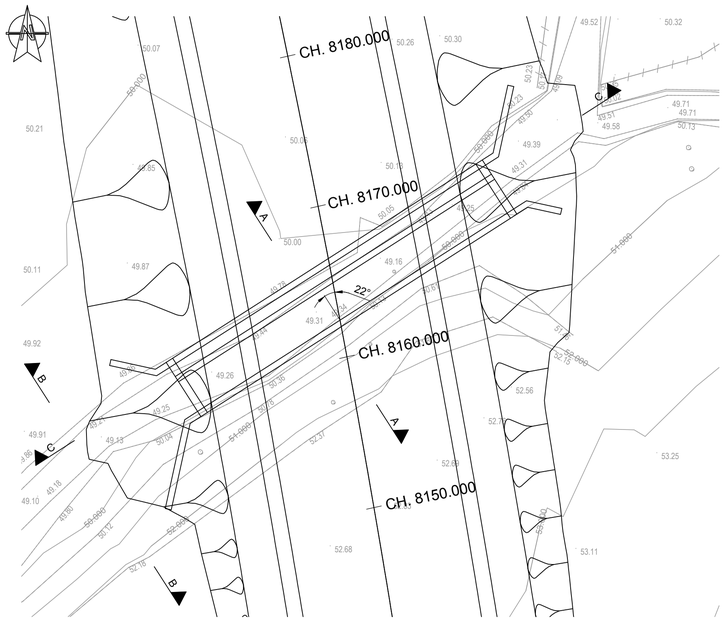
Site/Project:
A487 CAERNARFON TO BONTNEWYDD BYPASS

Title:
S113A FP 36 UNDERBRIDGE GENERAL ARRANGEMENT (WG No. A487 625)

Drawn: M.Barka		Checked: A.Jarman	
Designed: A. GROVES		Approved: A.Groves	
Date: 01/06/15	Scale: AS SHOWN	A1	Sheet:

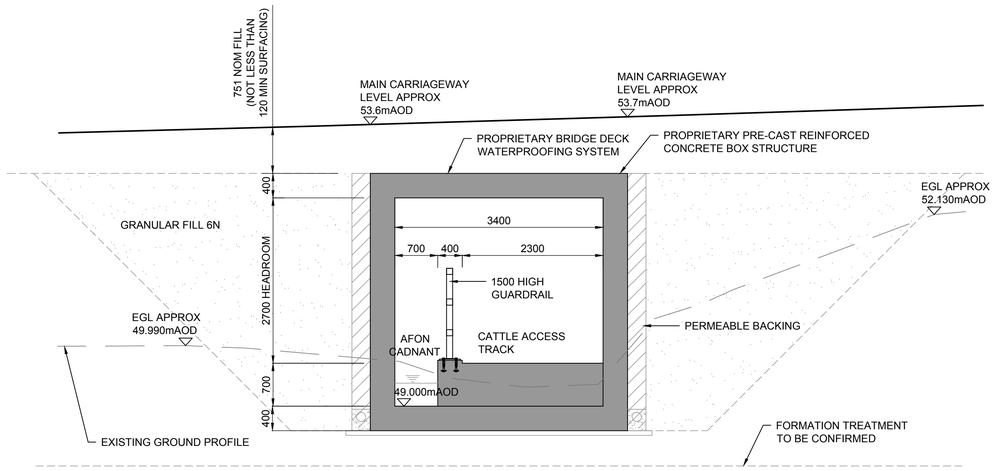
Container Number: 3513874-PB-SBR-113A-DR-S-00001 — Revision: P01

© Copyright Parsons Brinckerhoff



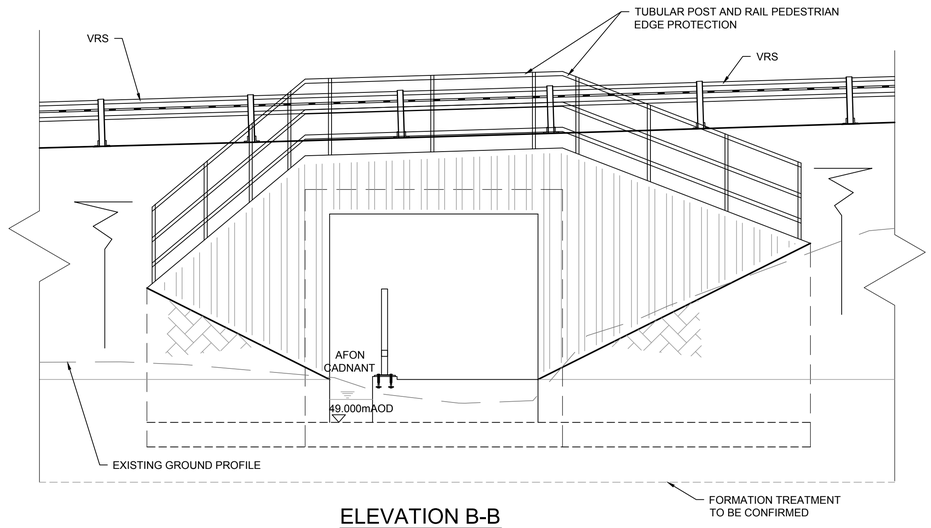
PLAN

SCALE 1:200



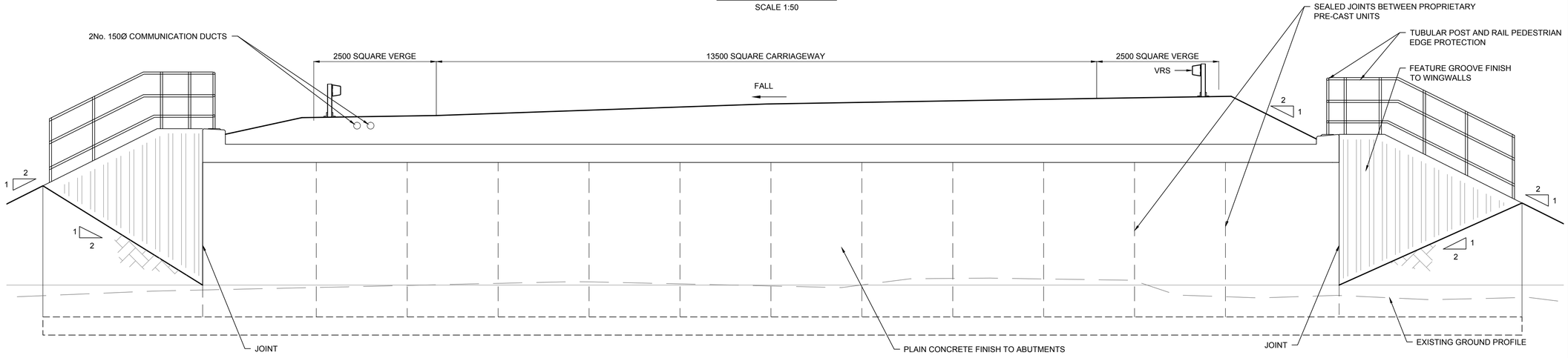
SECTION A-A

SCALE 1:50



ELEVATION B-B

SCALE 1:50



ELEVATION C-C

SCALE 1:50

© Crown copyright and database rights 2015
Ordnance Survey 0100031673
© Getmapping plc.

NOTES

A1

1. THIS IS A C.A.D. DRAWING AND SHOULD NOT BE AMENDED BY HAND.
2. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

HEALTH AND SAFETY INFORMATION

SIGNIFICANT OR EXCEPTIONAL RISKS ARE IDENTIFIED BELOW

CONSTRUCTION PHASE

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE WORKS INFORMATION FOR DETAILS OF THE RISKS ASSOCIATED WITH THIS WORK.
2. IN PREPARATION OF CONSTRUCTION METHOD STATEMENTS CONSIDERATION SHOULD BE GIVEN TO THE CLOSE PROXIMITY OF ANY STRUCTURES THAT MAY BE AFFECTED BY CONSTRUCTION.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE DRAWING.
   i. NOTHING SIGNIFICANT OR UNUSUAL.
4. THE CONTRACTOR SHALL REFER TO STATUTORY UNDERTAKERS LAYOUT DRAWINGS AND IDENTIFY LOCATIONS OF EXISTING UNDERGROUND SERVICES PRIOR TO CARRYING OUT EXCAVATION WORKS.

MAINTENANCE / OPERATION / DECOMMISSIONING / DEMOLITION PHASES

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE MAINTENANCE AND REPAIR STRATEGY FOR DETAILS OF THE RISKS ASSOCIATED WITH THE MAINTENANCE, OPERATION, DECOMMISSIONING AND DEMOLITION PHASES.
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE HEALTH AND SAFETY FILE(S) PRODUCED AND HANDED OVER ON COMPLETION OF THIS PROJECT.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE AS-BUILT DRAWING.
   i. NOTHING SIGNIFICANT OR UNUSUAL

Rev	Date	Description	By	Chk	App
P01	12/06/2015	FOR INFORMATION	MB	AMJ	AKG

FIT FOR INFORMATION

EC HARRIS BUILT ASSET CONSULTANCY
Llywodraeth Cymru
Welsh Government
Balfour Beatty
JONES BROS CIVIL ENGINEERING UK
PARSONS BRINCKERHOFF
TACP
Ty Glyn, Canol Y Dre, Ruthin Denbighshire Tel: 01824 703661

Site/Project:

A487 CAERNARFON TO BONTNEWYDD BYPASS

Title:

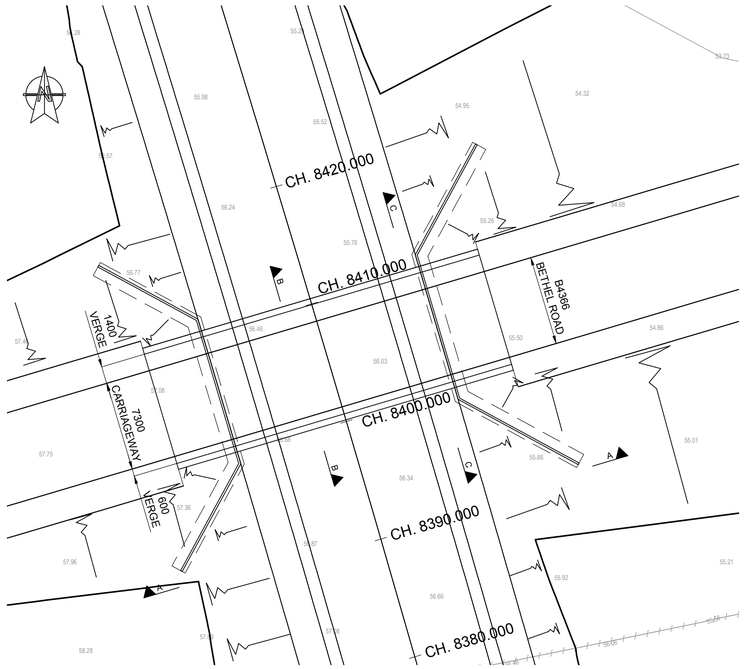
S114 AFON CADNANT CATTLE CREEP / CULVERT GENERAL ARRANGEMENT (WG A487 631)

Drawn: M.Barka		Checked: A.Jarman	
Designed: A. GROVES		Approved: A.Groves	
Date: 26/05/15	Scale: AS SHOWN	A1	Sheet:

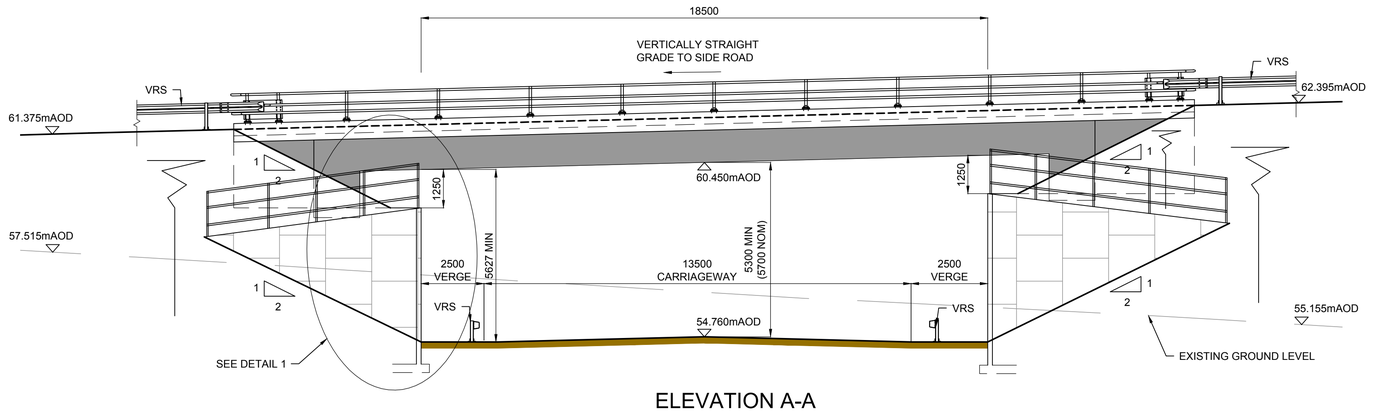
Container Number: 3513874-PB-SBR-114-DR-S-00001

Revision: P01

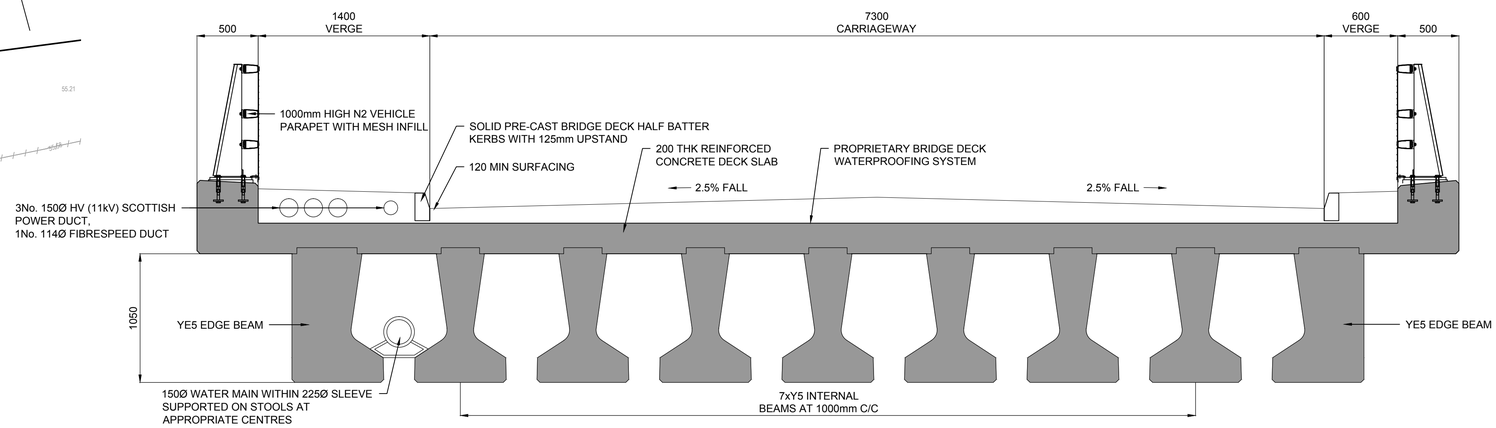
© Copyright Parsons Brinckerhoff



PLAN
SCALE 1:250

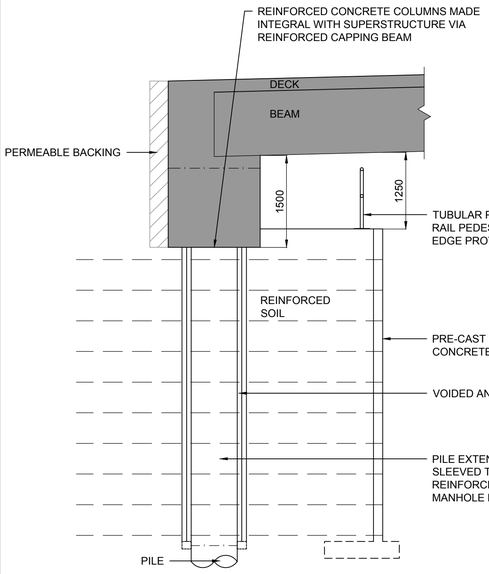


ELEVATION A-A
SCALE 1:100

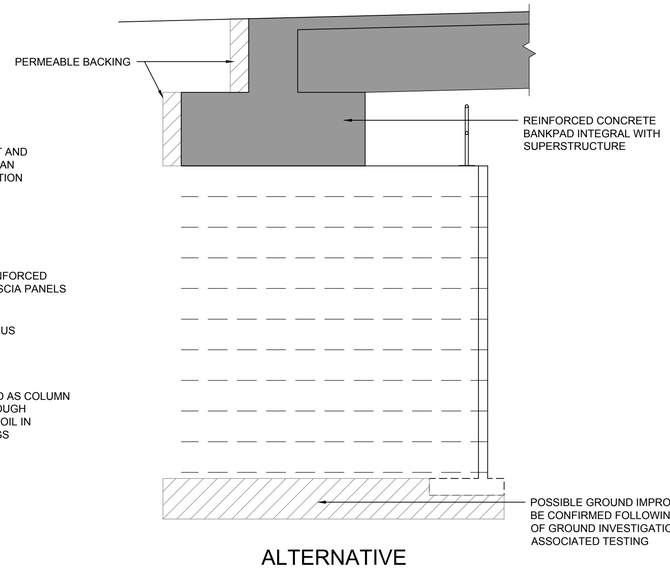


BEAM INSTABILITY DURING CONSTRUCTION.

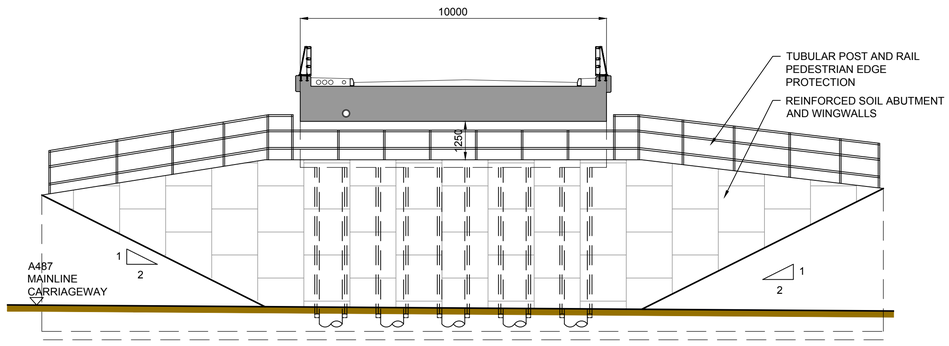
SECTION B-B
SCALE 1:25



DETAIL 1
SCALE 1:50



ALTERNATIVE DETAIL 1
SCALE 1:50



ELEVATION C-C
SCALE 1:100

© Crown copyright and database rights 2015 Ordnance Survey 0100031673
© Getmapping plc.

NOTES

1. THIS IS A C.A.D. DRAWING AND SHOULD NOT BE AMENDED BY HAND.
2. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

HEALTH AND SAFETY INFORMATION

SIGNIFICANT OR EXCEPTIONAL RISKS ARE IDENTIFIED BELOW

CONSTRUCTION PHASE

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE WORKS INFORMATION FOR DETAILS OF THE RISKS ASSOCIATED WITH THIS WORK.
2. IN PREPARATION OF CONSTRUCTION METHOD STATEMENTS CONSIDERATION SHOULD BE GIVEN TO THE CLOSE PROXIMITY OF ANY STRUCTURES THAT MAY BE AFFECTED BY CONSTRUCTION.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE DRAWING.
   i. BEAM INSTABILITY DURING CONSTRUCTION.
4. THE CONTRACTOR SHALL REFER TO STATUTORY UNDERTAKERS LAYOUT DRAWINGS AND IDENTIFY LOCATIONS OF EXISTING UNDERGROUND SERVICES PRIOR TO CARRYING OUT EXCAVATION WORKS.

MAINTENANCE / OPERATION / DECOMMISSIONING / DEMOLITION PHASES

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE MAINTENANCE AND REPAIR STRATEGY FOR DETAILS OF THE RISKS ASSOCIATED WITH THE MAINTENANCE, OPERATION, DECOMMISSIONING AND DEMOLITION PHASES.
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE HEALTH AND SAFETY FILE(S) PRODUCED AND HANDED OVER ON COMPLETION OF THIS PROJECT.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE AS-BUILT DRAWING.
   i. NOTHING SIGNIFICANT OR UNUSUAL

Rev	Date	Description	By	Chk	App
P01	12/06/2015	FOR INFORMATION	MB	AMJ	AKG

FIT FOR INFORMATION

EC HARRIS BUILT ASSET CONSULTANCY
Llywodraeth Cymru Welsh Government
RAMBOLL
Balfour Beatty
JONES BROS CIVIL ENGINEERING UK
PARSONS BRINCKERHOFF
TACP
Ty Glyn, Caerdydd Y Dre, Ruthin Denbighshire Tel: 01824 703661

Site/Project:

A487 CAERNARFON TO BONTNEWYDD BYPASS

Title:

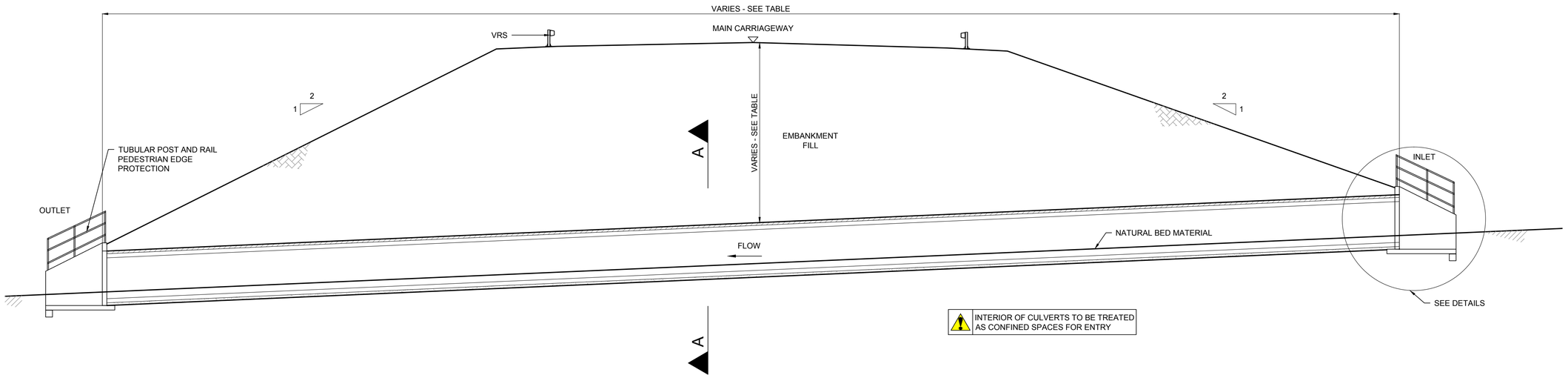
S115 BETHEL ROAD OVERBRIDGE GENERAL ARRANGEMENT (WG A487 635)

Drawn: M.Barka		Checked: A.Jarman	
Designed: A. GROVES		Approved: A.Groves	
Date: 03/06/15	Scale: AS SHOWN	A1	Sheet:

Container Number: 3513874-PB-SBR-115-DR-S-00001

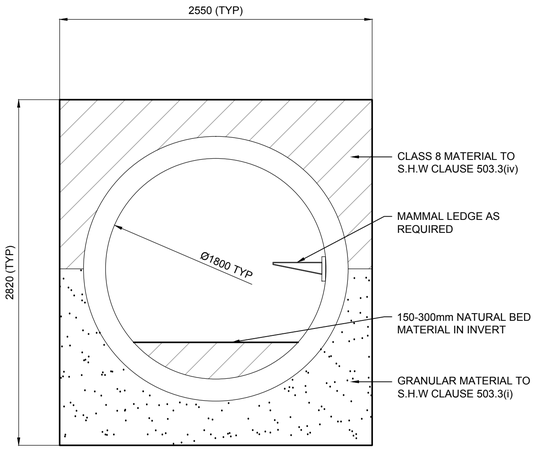
Revision: P01

© Copyright Parsons Brinckerhoff



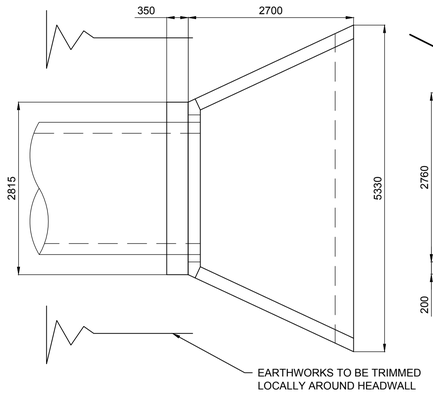
TYPICAL ELEVATION

SCALE 1:100



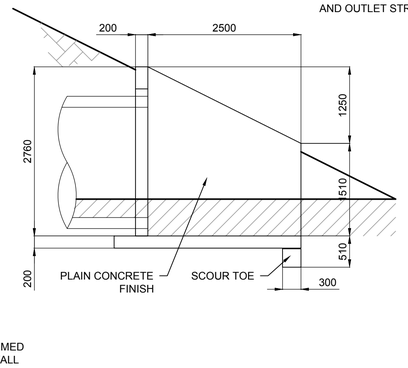
SECTION A-A

SCALE 1:25



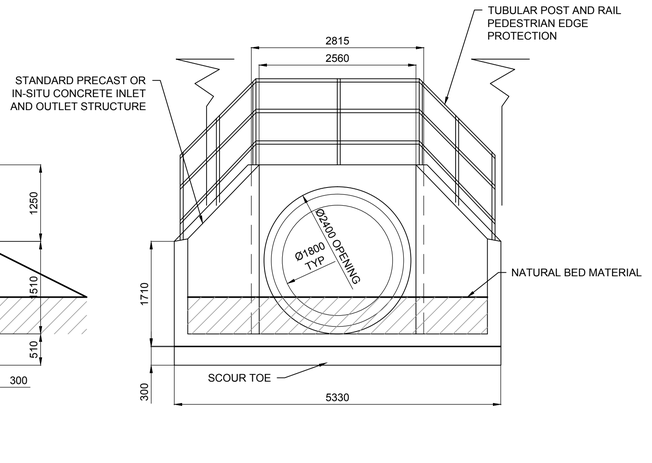
PLAN

SCALE 1:50



SECTION

SCALE 1:50



ELEVATION

SCALE 1:50

HEADWALL DETAIL (TYPICAL)

BASED ON 1800Ø PIPE

Structure	WG Asset No.	Type	Indicative Length (m)	Indicative Depth of Cover (m)	Trash/Debris Screen	Environmental Considerations
S101	A487 550 C68	1.8m dia. pipe	57.2	7.1	No	Bat flight path.
S104	A487 571 C80	1.8m dia. pipe	35.2	1.8	No	Bat flight path. Animal ledge
S109A	A487 601 C01	1.8m dia. pipe	36.4	6.4	No	Bat flight path. Animal ledge
S109B	N/A	0.6m dia. Pipe*	23.6	1.6	Yes	Bat flight path.
S110	A487 601 C73	1.8m dia. pipe	30.2	2.8	No	Bat flight path.
S110A	A487 601 C58	1.8m dia. pipe	23.2	1.3	No	Bat flight path.
S111A	A487 611 C08	1.8m dia pipe	29.6	1.5	Yes (grille)	Bat flight path. Note - bat only culvert – no watercourse.
S111B	A487 611 C09	1.5m dia. pipe	14.2	1.3	No	Bat flight path.
S112A	A487 621 C61	1.5m dia. pipe	15	1.3	No	Bat flight path.
S112B	A487 621 C59	1.5m dia. pipe	32.2	1.4	No	Bat flight path.
S112C	N/A	0.6m dia. Pipe*	32.7	2.4	Yes	Bat flight path.
S114A	A487 631 C08	1.8m pipe	29.4	3.2	No	Bat flight path. Animal ledge.
S115A	A487 635 C01	1.8m pipe	55.5	8.8	No	Bat flight path. Animal ledge.
S115B	N/A	1.8m pipe	53.5	5	No	Bat flight path.

* Not considered as a "Structure" in accordance with BD2/12

TABLE OF PROPOSED CULVERTS

© Crown copyright and database rights 2015
Ordnance Survey 0100031673
© Getmapping plc.

NOTES

A1

1. THIS IS A C.A.D. DRAWING AND SHOULD NOT BE AMENDED BY HAND.
2. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

HEALTH AND SAFETY INFORMATION

SIGNIFICANT OR EXCEPTIONAL RISKS ARE IDENTIFIED BELOW

CONSTRUCTION PHASE

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE WORKS INFORMATION FOR DETAILS OF THE RISKS ASSOCIATED WITH THIS WORK.
2. IN PREPARATION OF CONSTRUCTION METHOD STATEMENTS CONSIDERATION SHOULD BE GIVEN TO THE CLOSE PROXIMITY OF ANY STRUCTURES THAT MAY BE AFFECTED BY CONSTRUCTION.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE DRAWING.
   i. INTERIOR OF CULVERTS TO BE TREATED AS CONFINED SPACES FOR ENTRY
4. THE CONTRACTOR SHALL REFER TO STATUTORY UNDERTAKERS LAYOUT DRAWINGS AND IDENTIFY LOCATIONS OF EXISTING UNDERGROUND SERVICES PRIOR TO CARRYING OUT EXCAVATION WORKS.

MAINTENANCE / OPERATION / DECOMMISSIONING / DEMOLITION PHASES

1. PLEASE REFER TO THE HAZARD RISK REGISTER AND THE MAINTENANCE AND REPAIR STRATEGY FOR DETAILS OF THE RISKS ASSOCIATED WITH THE MAINTENANCE, OPERATION, DECOMMISSIONING AND DEMOLITION PHASES.
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE HEALTH AND SAFETY FILE(S) PRODUCED AND HANDED OVER ON COMPLETION OF THIS PROJECT.
3. RESIDUAL HAZARDS ARE LISTED HERE AND REFERENCED ON THE AS-BUILT DRAWING.
   i. NOTHING SIGNIFICANT OR UNUSUAL

Rev	Date	Description	By	Chk	App
P01	23/06/2015	FOR INFORMATION	MB	AMJ	AKG

FIT FOR INFORMATION

EC HARRIS BUILT ASSET CONSULTANCY
Llywodraeth Cymru Welsh Government
RAMBOLL
Balfour Beatty
JONES BROS CIVIL ENGINEERING UK
PARSONS BRINCKERHOFF
TACP
Ty Glyn, Caerol Y Dre, Ruthin Denbighshire Tel: 01824 703661

Site/Project:

A487 CAERNARFON TO BONTNEWYDD BYPASS

Title:

TYPICAL GENERAL ARRANGEMENT FOR CULVERTS

Drawn: M.Barka		Checked: A.Jarman	
Designed: A. GROVES		Approved: A.Groves	
Date: 16/06/15	Scale: AS SHOWN	A1	Sheet:

Container Number: 3513874-PB-SMN-CU-DR-S-00001 | Revision: P01

© Copyright Parsons Brinckerhoff

Appendix A.7 - Schedule of Main Environmental Consultations and Reviews

Schedule of Main Environmental Consultations and Reviews

Date	Description of consultation/ review	Attendees/ contributors	Overview of topics & issues covered	Outcomes/ actions
2nd Aug 2016	Production of final ES for publication	WSP PB, TACP	- All chapters reviewed and revised following further comments from WG and SEBs	- ES finalised for publication
7th July 2016	Consultation to go through changes to revised ES & SIAA for further comment	WG, NRW, GC, NMWTRA, JV, Ramboll	- Culvert design for Afon Rhyd - Water vole habitat - WFD assessment	- Further changes made to draft ES and SIAA in light of discussions
29th June 2016	Revision to draft ES following meetings and discussions with NRW	WSP PB, TACP	- Further revisions to Cultural Heritage and Nature Conservation chapters following discussions with GAPS, NRW and other SEBs	
25th May 2016	Site walkover to discuss nature conservation	TACP, NRW, JV	- S102 Afon Rhyd culvert design - Culvert design for LHB - Additional bat survey locations and crossing proposed by NRW	- Further changes to survey method and locations - Revised design proposed for S102
24th May 2016	Meeting to discuss a way forward with Pont Afon Rhyd and Lesser horseshoe bat (LHB) issues in ES/ SIAA	WG, NRW, JV, TACP, WSP PB, Dr Peter Fox (for TACP), David Williams (for TACP), Ramboll	- Bat surveys and mitigation proposals - Structure S102/ Afon Rhyd – discussion around culvert mitigation proposals for migratory fish	- Additional bat survey locations proposed, resulting in addition of A1-7 using static detectors And NRW 1,2 and 3.
11th Mar 2016	Revision to draft ES following comments from WG	WSP PB, TACP, WG	- WG reviewed the ES with specific focus on the Nature Conservation chapter following discussions with NRW. Main focus of comments in relation to bat mitigation, surveys and Afon Rhyd culvert design.	- Updated Nature Conservation chapter and SIAA

4th Mar 2016	Revision to draft ES following comments from SEBs	WSP PB, TACP, WG	- All draft chapters available for review at that time were revised having received comments from SEBs (NRW, GC, NMWTRA, GAT, GAPS).	-
9th Dec 2015	Environmental Liaison Group (ELG) meeting	WG, JV, WSP PB, NRW, TACP, Ramboll, MH, GC, GAPS, NMWTRA	- Presentation delivered on issues for all ES chapters with discussion between all parties. Refer to minutes in Appendix A.3 of the ES	
Oct/Nov 2015	Employer's Agent (Ramboll) review of draft ES	Ramboll	- Review of draft ES Vol 1-3. Comments and recommendations made.	- Revisions made to ES Vol 1-3. Draft ES issued to SEBs for review and comment.
9th July 2015	ELG meeting	WG, Ramboll, NRW, GC, JV, TACP WSP PB, Pearson Archaeology, GAT, NMWTRA	- Update of Scheme design, survey progress and other environmental issues. Refer to minutes in Appendix A.3 of the ES	
April 2015	Combined schedule of comments from consultees	WG, NRW, Cadw, GC, NMWTRA, GAPS	- All topics. Full scoping response included in Appendix A.2 of the ES.	- Scoping report issued March 2015
25th Feb 2015	ELG meeting	Ramboll , WG, NMWTRA, GAT, NRW, JV, TACP, WSP PB, GC	- Refer to minutes in Appendix A.3 of the ES.	- Refer to minutes in Appendix A.3 of the ES.
21st Oct 2014	ELG meeting 2	Ramboll, WG, NMWTRA, GAPS, NRW, JV, TACP, WSP PB, GC, MH, EC Harris, Cadw	- Scheme presentation and overview of main project environmental issues. Refer to minutes in Appendix A.3. of the ES.	
24th Nov 2009	Environmental Liaison Group (ELG) meeting 1	WAG, GCC, NWTRA, CCW, EAWG, TACP	- Overview of project process and environmental issues. Refer to minutes in Appendix A.3 of the ES for further detail.	