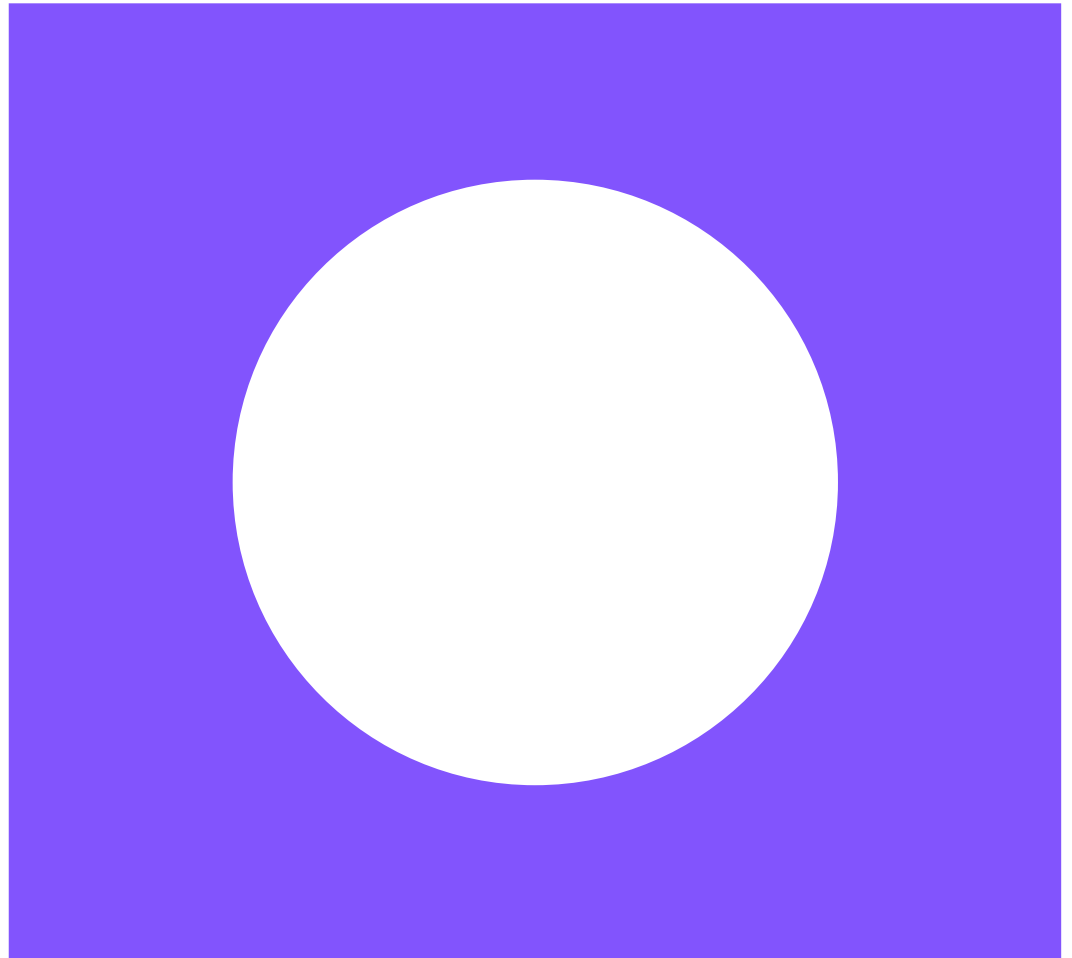




Bassaleg Bridge Optioneering and Design

Geomorphology Report

August 2025

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Geomorphology Report

August 2025

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Executive summary

Mott MacDonald has been commissioned by Newport City Council to undertake a geomorphological assessment of the planned Bassaleg Bridge replacement crossing of the River Ebbw (hereafter referred to as the Scheme). The Scheme was initiated following a structural assessment of Bassaleg Bridge and optioneering process that proposed an online replacement bridge to accommodate pedestrians, vehicular traffic, and existing services. This report provides a commentary on the geomorphological context of the River Ebbw, surrounding the planned new bridge and accompanying works.

The Scheme includes the bridge itself, a supporting abutment intruding into the right bank of the River Ebbw, associated scour protection along the bed and banks, and a flood wall to the south. The geomorphological appraisal includes a desk study, a site walkover and an appraisal of past river processes. The report also includes an impact assessment of the Scheme that analyses the hydraulic modelling results of the Scheme to understand the potential impacts to the geomorphology of the River Ebbw.

The River Ebbw is naturally dynamic but constrained by recent and historic development. Floodplain disconnection, pollution, and extensive bank protection have been identified as pressures. The Scheme is located in a straightened reach of the river where the floodplain has been built upon and disconnected from the river. The channel appears to have been narrowed and deepened, confining it over time. This acts to concentrate river energy through the confined section at the bridge crossing, over time potentially contributing to the existing bridge's instability.

The impact assessment has found that the Scheme's impact on flows during the operational and construction phases will be minor and localised to the footprint of the Scheme itself. The aperture of the bridge proposed under the Scheme will increase, and overall constriction of flow will decrease, with negligible effect on flows. Scour protection along the bed will mitigate any erosion risks and include an overlying substrate resembling baseline conditions, and scour protection along the bank will largely replace existing hard banks and maintain the capacity for vegetation to establish.

1 Introduction

1.1 Background

Mott MacDonald has been commissioned by Newport City Council to undertake a geomorphological assessment of the planned Bassaleg Bridge replacement crossing of the River Ebbw (hereafter referred to as the Scheme). The Scheme was initiated following the conclusion of a Structural Assessment Report¹ of the old Bassaleg Bridge in January 2023. An Options Selection Report² published in December 2023 outlined six options for the Scheme, and proposed an online replacement bridge to accommodate pedestrians, vehicular traffic, and existing services.

The aim of this study is to characterise the baseline geomorphology of the River Ebbw at the study site and surrounding area, determine potential impacts of the Scheme on the river hydromorphology, make recommendations for the design and identify suitable mitigation for potential impacts.

The report discusses the context of the site, with a desk study of its geomorphological character, the results of a site walkover visit, identifies past and potential future changes, and an impact assessment of the Scheme.

1.2 Site location

The old Bassaleg Bridge, as seen in Figure 1.1, is located on the River Ebbw at OS Grid Reference ST278870, off Caerphilly Road (Figure 1.2). The proposed bridge is located immediately upstream at ST278870.

Figure 1.1: Image of the old Bassaleg Bridge.

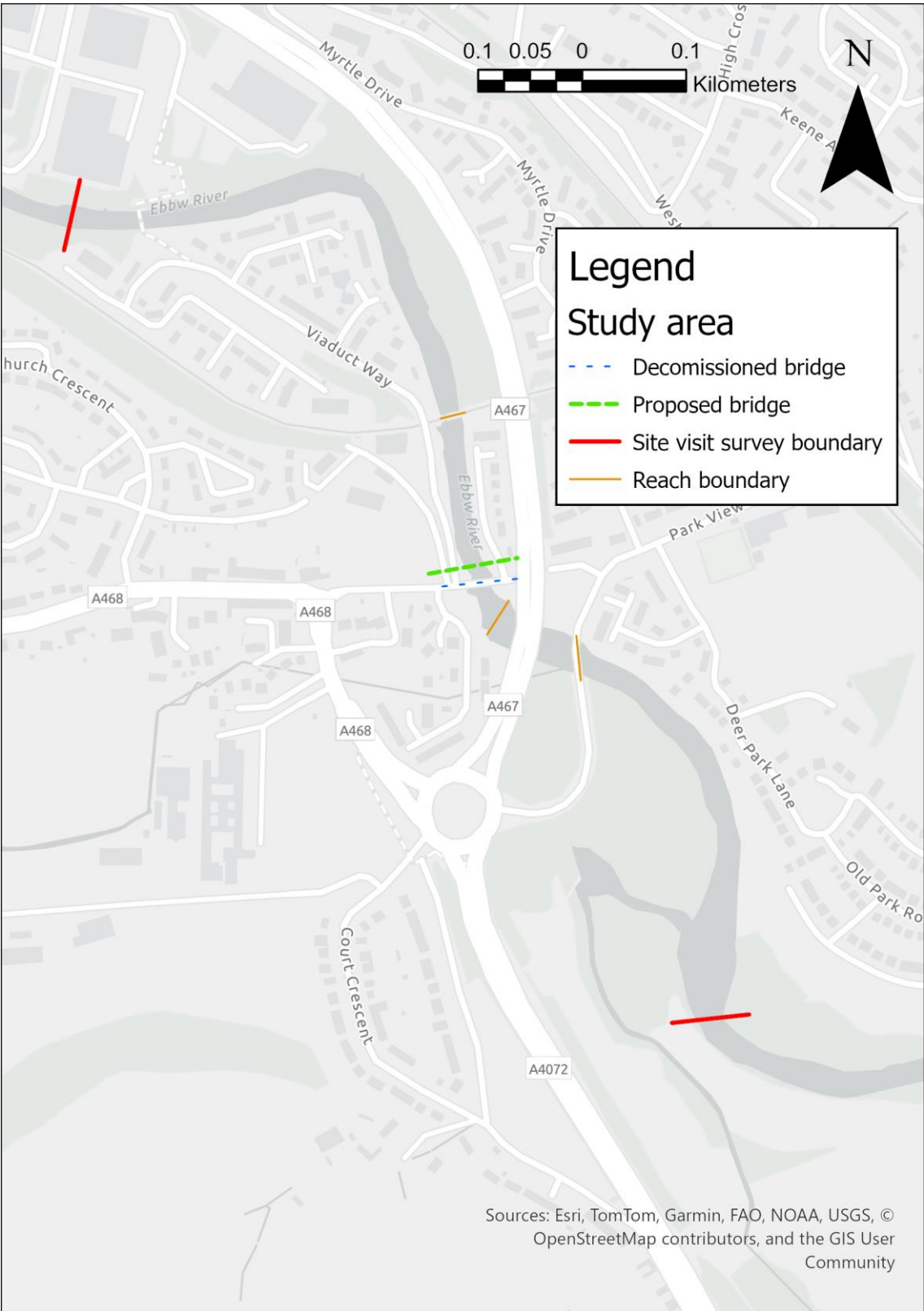


Source: Mott MacDonald, 2024

¹ Structural Assessment Report, Old Bassaleg Bridge, January 2023, Mott MacDonald

² Option Selection Report – Final, Old Bassaleg Bridge, December 2023, Mott MacDonald

Figure 1.2: Outline of survey reaches and location of the Scheme.



Source: Source: MottMacDonald, 2024

2 Methodology

To assess the baseline characteristics of the watercourse, a desk-based appraisal and site walkover survey were undertaken. Initial desk-based analysis covered an approximate 10km length to assess wider reach-scale forms and processes within the River Ebbw. This included a review of the planform, hydrology, underlying geology, land use and Water Framework Directive (WFD) baseline data. Historical channel changes were determined through analysis of historic maps, air photos and LiDAR data.

The geomorphological walkover survey covered 500m upstream and downstream of the existing Bassaleg Bridge crossing. This was conducted to assess the planform and flow characteristics, bank and substrate conditions, any depositional features, riparian and in-channel vegetation, and anthropogenic features.

Data from desk-based analysis and the site walkover were used to conduct a baseline geomorphology appraisal that established the current geomorphological processes occurring within the river, and the natural and anthropogenic drivers for change operating within the system. No previous studies on the fluvial geomorphology of the River Ebbw were available for this assessment.

Once the baseline conditions were characterised the potential impacts of the proposed Scheme were established. This included hydraulic analysis to determine the impacts of potential alterations to flow on river morphology and sediment transport. Finally, mitigation measures that may reduce the impact of the proposed Scheme on the fluvial geomorphology of the watercourse were identified.

2.1 Sources of information

The technical note has been informed by a desk-based analysis of publicly available information using sources:

- National LiDAR Programme³
- National River Flow Archive (NRFA) station 56002 – Ebbw at Rhiwderin⁴
- Ordnance Survey (OS) Mapping⁵
- British Geological Survey (BGS) 50k geology map viewer⁶
- Water Watch Wales WFD data⁷
- National Library of Scotland Historic Maps⁸

³ National LiDAR Programme, <https://www.data.gov.uk/dataset/f0db0249-f17b-4036-9e65-309148c97ce4/national-lidar-programme>, accessed Sep 2-24

⁴ NRFA Station Data for 56002 – Ebbw at Rhiwderin, <https://nrfa.ceh.ac.uk/data/station/info/56002>, accessed July 2024

⁵ Bing maps, Bing Maps - Directions, trip planning, traffic cameras and more, <https://www.bing.com/maps/>, accessed July 2024

⁶ British Geological Survey (BGS) Geology of Britain Viewer, Geology of Britain viewer - British Geological Survey, <https://geologyviewer.bgs.ac.uk/>, accessed July 2024

⁷ Water Watch Wales, naturalresourceswales.gov.uk, accessed July 2024

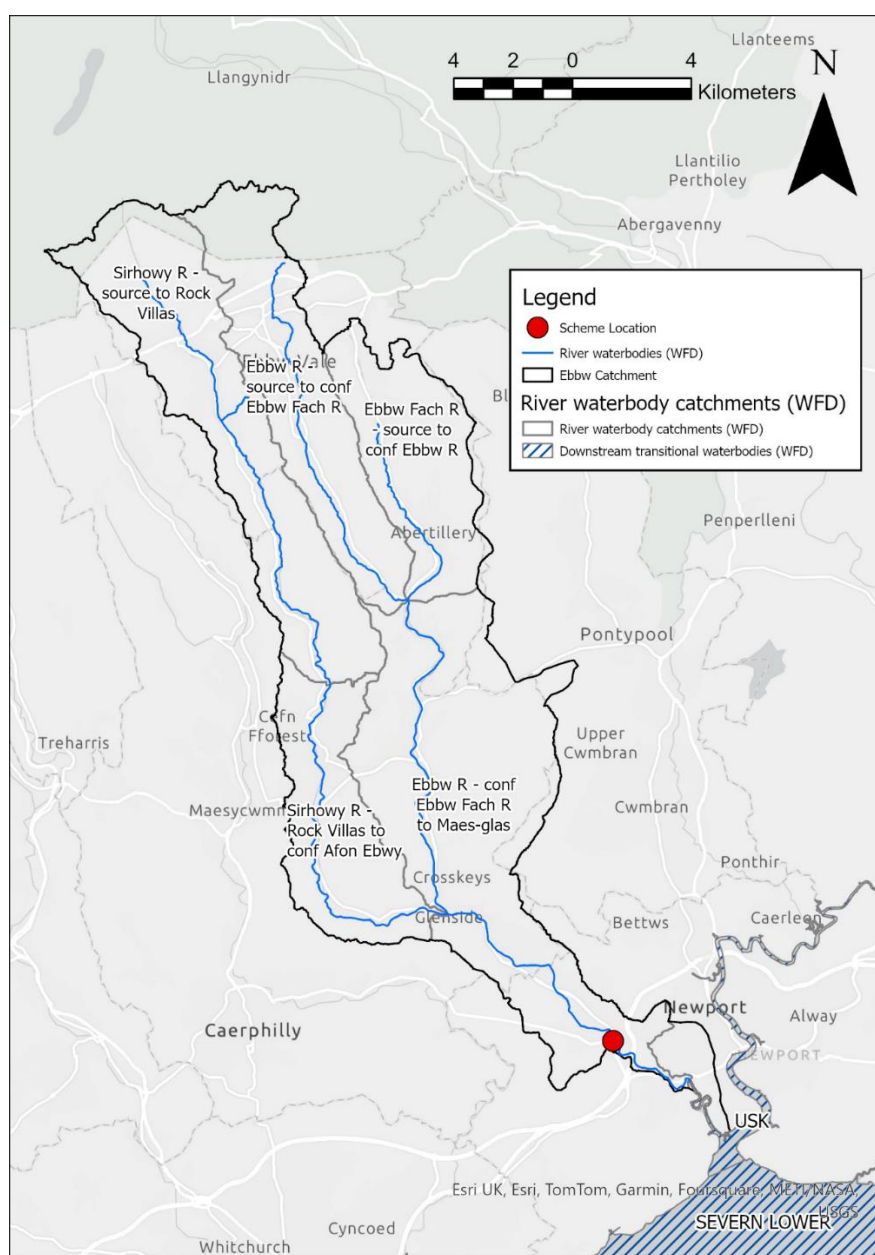
⁸ National Library of Scotland Georeferenced Maps, <https://maps.nls.uk/geo/explore/>, accessed July 2024

3 Catchment context

3.1 Watercourse

The River Ebbw catchment extends from the upland Bannau Brycheiniog National Park (557mAOD) to Newport. The river originates at the confluence between two smaller river headwaters, Ebbw Fach (Mynydd Llangynidr), and Ebbw Fawr, (Mynydd Llangattwg)⁴. The river flows through several urban areas, such as Ebbw Vale, Abertillery and Newbridge, before reaching Newport where it joins the tidally influenced reach of the River Usk (6.5km downstream) that flows into the lower Severn Estuary, a further 1.2km downstream.

Figure 3.1: Catchment of the River Ebbw, divided into WFD surface water bodies.



Source: MottMacDonald, 2024, Water Watch Wales⁷

3.2 Hydrology

The nearest NRFA station at Rhiwderin⁴ lies 3.1km upstream of the Scheme and records a catchment 216km² in size.

The river's median annual flood flow (QMED) is 106m³/s, with a mean flow of 7.416m³/s, and a Q95 of 1.324m³/s. The largest recorded flow event in the digital archive was on 16 February 2020, where the flow reached 197.6m³/s, with a stage of 3.089m.

The base flow index (BFI) of 0.55 indicates a moderate-to-high base flow component.

3.3 Geology

British Geological Survey (BGS)⁶ data indicates that the bedrock geology of the lower catchment mainly comprises very low permeability sedimentary bedrock (Devonian mudstones and sandstones). Conversely, the catchment upstream from Risca primarily comprises Carboniferous sandstones, mudstones, and siltstones, with moderate permeability. These rocks include a number of coal measures, which were extensively mined during the 18th to 20th centuries.

Superficial deposits within the lower catchment include Quaternary alluvium (clay, silt, and gravel) adjacent to the river. Quaternary head (clay, silt, and gravel) and glaciofluvial (sand and gravel) deposits are more prevalent upstream. Devensian till (diamicton) occurs away from the river corridor.

3.4 Land use

Land use within the catchment is mixed. The upper parts of the catchment are rural, incorporating parts of the Bannau Brycheiniog National Park. These areas comprise mostly heath grassland with increasing grassland and woodland further downstream.

The river flows through some significant urban areas, including Risca, Cwmcarn, Abarcarn, Newbridge forming a semi-continuous urban/suburban land use surrounding the River Ebbw and its tributaries within the valleys. Urban areas are surrounded by moors and heathland, broad-leaved forest and coniferous forest.

The region has a notably significant industrial past, with the whole region transformed during the Industrial Revolution with the opening of the Ebbw Vale Steelworks and associated coal mining in the surrounding valleys. Large areas have been re-developed following the decline of mining and steel industries, but the industrial past retains an important impact on the landscape.

Land use directly at the study area is largely suburban with smaller areas of woodland and agriculture.

The site of the former Castle Steel Works is located 600m upstream of the study site. Much of the area has been redeveloped into housing.

3.5 Water Framework Directive

The WFD status of water bodies 10km downstream from the Scheme, and 2km upstream have been identified. This includes the River Ebbw 'Ebbw R - conf Ebbw Fach R to Maes-glas' (GB109056026910) which intersects the Scheme, and the 'Usk' transitional (GB530905415404) water body which also includes the tidal area of the River Ebbw 3.9km downstream from the

Scheme. Table 2.1 displays baseline information for both water bodies from the Cycle 3 classification data⁷. The WFD assessment is provided in a separate report⁹.

Table 3.1: WFD baseline summary of nearby water bodies.

WFD waterbody	Distance from the site	Overall status	Ecological status	Chemical status	Heavily modified designation
Ebbw R - conf Ebbw Fach R to Maes-glas GB109056026910	Within	Moderate	Moderate	Moderate	Heavily modified
USK GB530905415404	3.9km	Moderate	Moderate	High	Heavily modified

Source: NRW, 2025⁷

⁹ Bassaleg Bridge WFD Assessment | 100119581-MMD-XX-XX-RP-GM-0002

4 Site walkover

A site walkover of the River Ebbw was undertaken by two fluvial geomorphologists from Mott MacDonald on the 12th August 2024. The weather at the time was dry, there had been no significant rainfall and flow was low. The site walkover was undertaken along the River Ebbw approximately 500m upstream and approximately 500m downstream from the site of the old bridge. More detail of the site walkover, including images, is included in Appendix A.

From the site walkover, the river was determined to have a sinuous platform, with a notably straight section at the bridge. The river throughout the walkover was constrained by reinforcements including rip-rap, blockstone walls, and concrete beds.

The river can be delineated into four reaches, as shown in Figure 4.1.

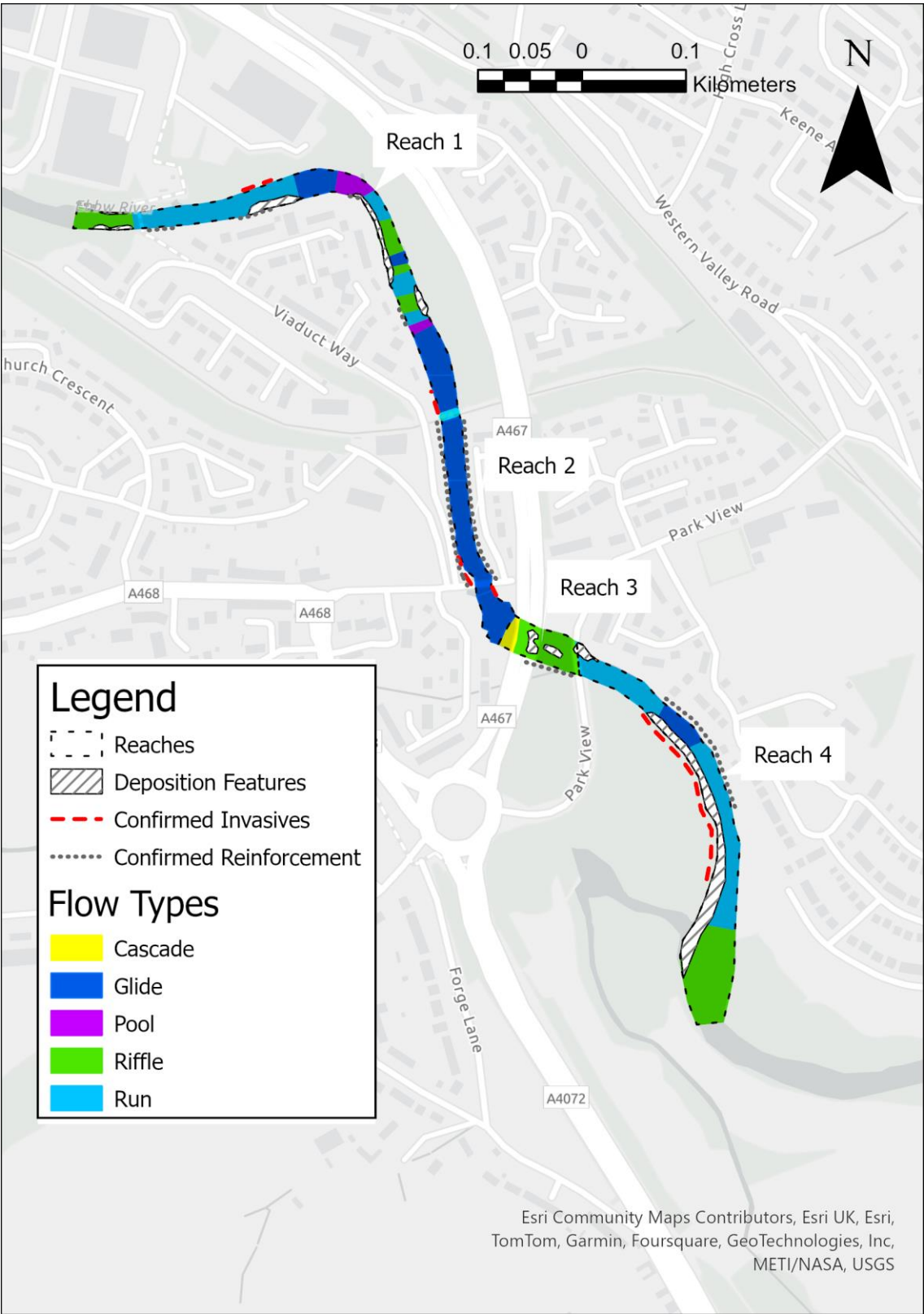
- Reach 1 = upstream of the footbridge to the railway viaduct
- Reach 2 = viaduct to the weir
- Reach 3 = weir to motorway bridge, and;
- Reach 4 = motorway bridge to the downstream meander at the study area boundary.

The geomorphological characteristics of the study reaches are summarised in Table 4.1. Much of the river corridor is urban, with occasional pockets of deciduous woodland. The river had a gravel bed and was mostly dominated by pool-riffle type morphology. Reach 2 (where the Scheme is located), has a much lower flow diversity compared to the other reaches, and at the time of survey was impounded by the downstream weir.

Table 4.1: Summary of reach scale geomorphology based on walkover survey.

Table Parameter		Reach 1	Reach 2	Reach 3	Reach 4
Channel gradient		Moderate	Low	Moderate	Low
Representative channel dimensions (m)	Bankfull width	20.0	20.0	34.0	34.0
	Bankfull depth	3.0	4.0	6.0	1.0
	Wetted width	15.0	17.0	20.0	15.0
	Wetted depth	0.2	1.5	0.5	0.3
Adjacent land use type	Left bank	Deciduous woodland	Urban	Urban	Urban
	Right bank	Urban	Urban	Deciduous woodland	Deciduous woodland
Dominant flow type		Run	Glide	Riffle	Glide
Dominant substrate		Cobble	Gravel	Cobble	Cobble
Lateral bars present		Yes	No	Yes	Yes
Mid channel bars present		No	No	Yes	No
Bars – dominant material		Cobble	N/A	Cobble	Cobble
Planform		Passive meandering	Passive meandering	Passive meandering	Passive meandering
Riparian vegetation		Deciduous woodland and shrub	Improved grassland and shrub	None	Deciduous woodland and scrub

Figure 4.1: Map of river flow types and features from site walkover



Source: MottMacDonald, 2024

5 Baseline geomorphological appraisal

5.1 Planform and morphology

Understanding the geomorphological conditions is a critical part of ensuring the long-term stability of the new bridge. To understand the mutual impacts between the watercourse form and function, and bridge stability, an understanding of the baseline geomorphology is important. Scour behind the right pier of the old, decommissioned bridge shows the potential for fluvial processes to undermine bridge stability.

The River Ebbw within the study area is currently a passive meandering river. The overall gradient of the river is relatively high, at about 0.010 (Figure 5.1) dropping from c.400m AOD to around 30mAOD. The study area is located within the lower end of the river system, where the gradient decreases to about 0.005. Channel sinuosity within the study area is relatively low, with the sinuosity index (SI) at around 1.17. Figure 5.2 shows the watercourse profile within proximity of the study area.

The drainage configuration is strongly controlled by the underlying geology, forming a trellis pattern in the upper parts of the catchment. The river is naturally confined by relatively steep valley sides for most of its length, however valley bottoms are typically alluvial, with floodplains well-developed. From Newport to Brynmawr, the river corridor is mostly urban, which has increased confinement and constrained the river along most of its length. The study area is at the lower end of the river system, where gradient decreases and the river valley widens prior to discharge in the Usk and ultimately the Severn Estuary. At the study site, the natural floodplain is about 600m wide.

The river is relatively high energy and pool-riffle sequences are well-developed along most of the river, the notable exception being impounded areas such as upstream of the weir crossing. Depositional features include gravel bars, mostly associated with meander bends and downstream of tributaries, and riffles. These features suggest active sediment transport of coarse material.

Figure 5.1: Elevation of the river from Dock's Way (ST3043885720) to the Carno Reservoir (SO1653212920) according to National LiDAR Programme data³.

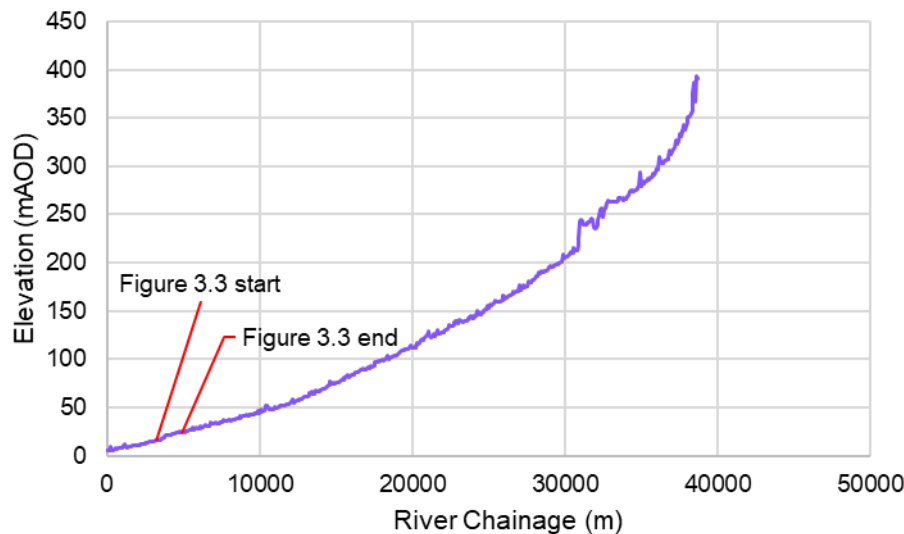
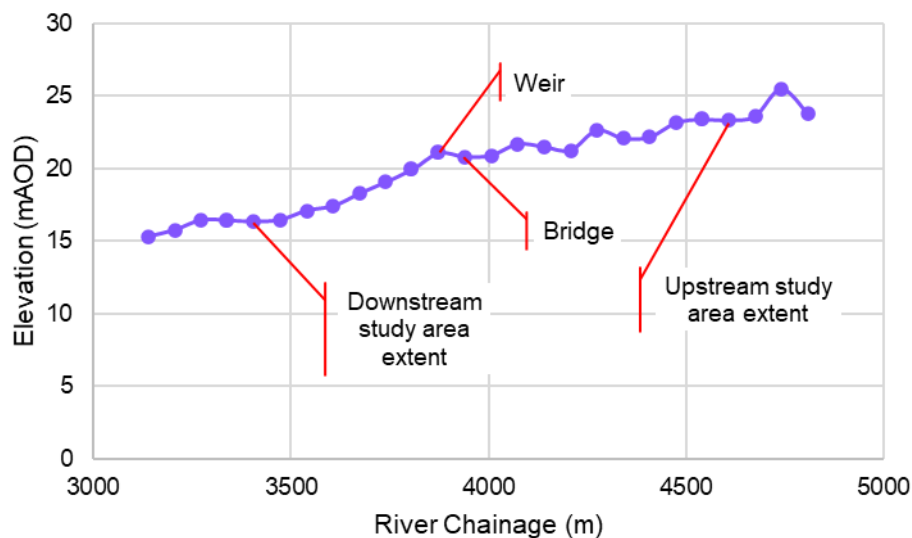


Figure 5.2: Elevation of the river from extents shown in Figure 3.2 according to National LiDAR programme data³.



5.2 Long-term geomorphological drivers

The Newport area was glaciated during the Quaternary glaciations, which likely sculpted river valleys, setting the framework for the modern drainage distribution. These glaciations left behind a thick layer of till, forming the valley sides. The current level of the River Ebbw and surrounding borehole information suggests the river has likely progressively incised down through these deposits, reaching the underlying bedrock at times, probably during times of sea level (and consequently base level) fall. Dominant trends were likely erosional, and the remnants of previous interglacial periods are seen through the occurrence of stepped Quaternary fluvial terraces, the nearest being 600m downstream from the study area at Tredegar Park.

The Holocene floodplain is about 300m wide in the study area, widening to about 500m past Pye Corner. Borehole data suggests the valley floor is filled with about 8m depth of Holocene alluvium (mostly gravel). This suggests Holocene trends were primarily aggradational. The River Ebbw was likely very dynamic, with active meandering across the floodplain. This would have progressively infilled the valley floor to the present level, probably through the progressive migration of point bars. This natural floodplain development and river adjustment has likely been halted by historical modification of the river corridor and current river management as well as reduced sediment supply.

5.3 River modification and management

Until the 18th century, the catchment and river corridor were sparsely populated. Direct modifications to the river and river corridor were probably limited to reclamation of floodplain areas for agriculture, and damming of the channel and tributaries for watermills. However, the catchment was transformed during the Industrial Revolution when the area became an important industrial centre for the iron and coal industry.

The underlying geology of the catchment includes a number of coal measures and forms part of the South Wales Coal Measures Group. These units were extensively quarried during the 18th-20th Centuries¹⁰. The proximity to coal brought significant industry to the region, most notably steelworks. The steep topography meant such industry was typically situated on valley bottoms along the natural river corridor. An extensive network of roads and railway lines were constructed, mostly adjacent to the River Ebbw and its tributaries. The course of the river was likely modified and extensive bank protection has effectively fixed the river to a set planform. Spoil and other colliery waste was distributed along the river corridor¹¹, which probably raised the floodplain levels, further reducing lateral connectivity. Leaching of pollutants from this waste continue to be a source of pollution for the river.¹²

At the study site, the river corridor is almost entirely urbanised upstream of the weir. The floodplain has been developed for housing, and ground levels have likely been altered to reduce flood risk to those receptors. The river appears to have been straightened for the construction of Forge Mews. In addition, a housing estate was constructed in 2004 on the right bank upstream of the viaduct. The construction of Viaduct Way, the access road for this development, appears to have further narrowed the channel. The river is now disconnected from its former floodplain at the Scheme site, and the channel is constrained by extensive bank protection that prevents natural bank migration and could encourage erosion of the bed to occur.

Downstream of the weir, the channel displays a somewhat more natural alignment; however, the river is crossed by several major roads which have created fixed points, preventing natural channel migration. At Tredegar Park, whilst the right bank remains somewhat natural, the left bank floodplain has been developed for housing in 2016. The river is now embanked on this side and channel migration is prevented by rock revetment and gabion baskets.

5.4 Recent channel changes

Recent channel changes within the study area have been investigated through historical map analysis by comparing OS maps⁸ from 1892 to 1914 mapping with present day satellite imagery. Aside from possible channel narrowing relating to the recent housing developments (outlined in Section 5.3 above) channel changes are restricted to areas immediately

¹⁰ Coal Mines - Wales - Northern Mine Research Society (nmrs.org.uk), accessed 15/09/24

¹¹ [View map | DataMapWales \(gov.wales\)](#), accessed 15/09/24

¹² NRW (2016). South East Valleys Management Catchment Summary. Available at: https://cdn.naturalresources.wales/media/679387/2016_updated-south-east_valleys_catchment_summary_nrw.pdf, accessed 15/09/24

downstream of the old bridge crossing at Tredegar Park. Imagery suggests some lateral channel migration of the right bank and a slight increase in sinuosity (Figure 5.3). The distribution of bars and in-channel islands has changed over time.

An eroding bank indicating active channel migration was observed on the site walkover on the right bank at Tredegar Park. However, natural channel migration is largely restructured due to extensive bank protection.

5.5 Future directory of change

A full analysis of the future directory of change is not possible without a full fluvial audit of the catchment. However, from the investigations undertaken as part of this study it is likely that the extensive anthropogenic alteration is likely having an impact on the future direction of change within the river system.

The river is naturally dynamic, but the extensive urbanisation and associated channel management and modification has meant that large parts of the river are now fixed, and the planform largely passive. Whilst historic coal mining and associated activities probably increased sediment supply to the river, the extensive urbanisation of the river corridor and prevalence of bank protection is likely currently restricting sediment supply.

The development of the river corridor and raising of floodplain levels has significantly reduced floodplain connectivity. High flows, which would naturally spill on to the floodplain are now confined to channels, resulting in higher flow velocities and increased stream power than would naturally be present.

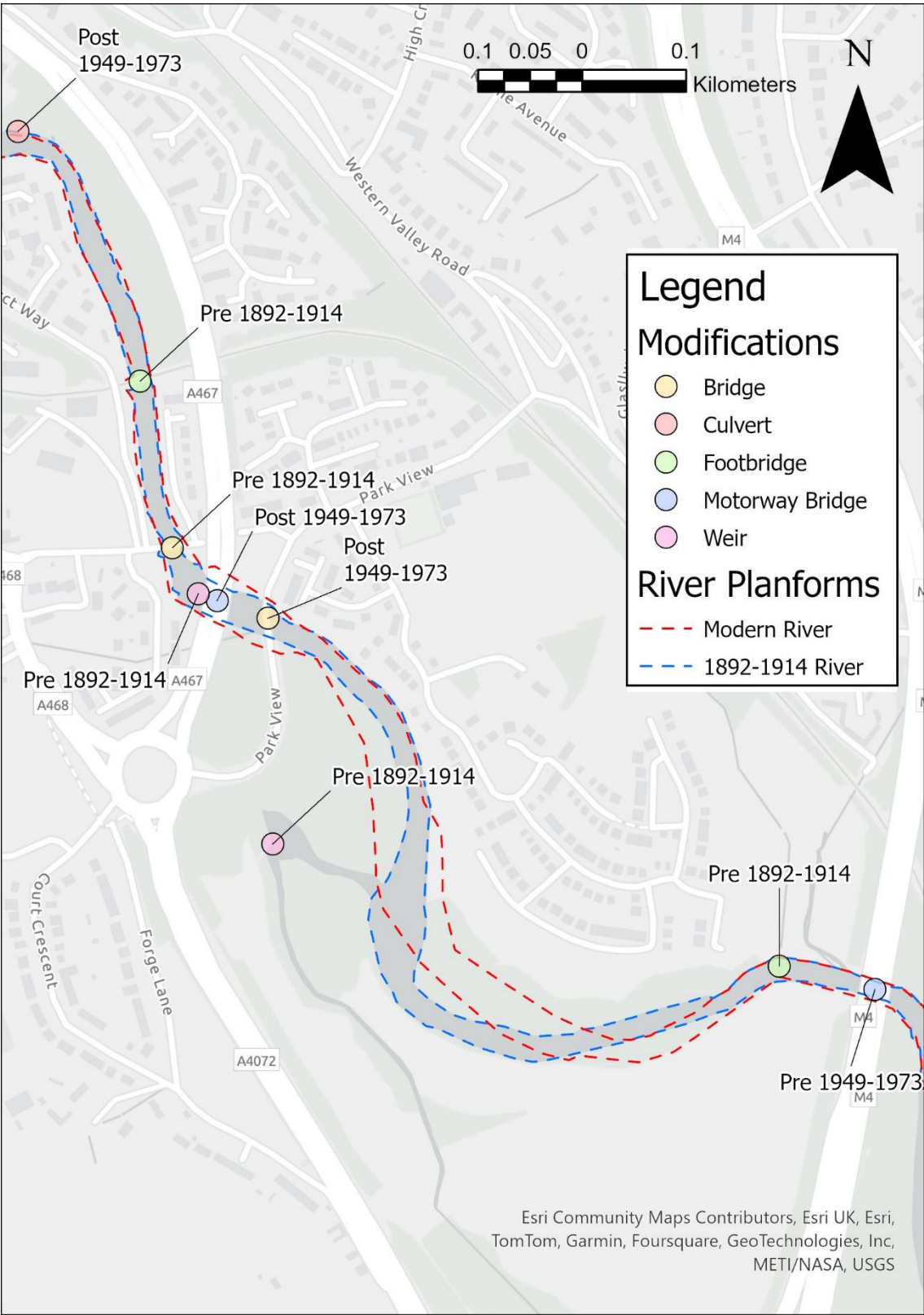
Considering the above, it is likely that natural channel adjustment in response to future pressures such as climate change has been highly restricted. Furthermore, it is likely that the river at the study site will be prone to ongoing incision (bed erosion) given the hard bank protection. The downstream weir is currently in poor condition, and its ongoing failure could result in a rapid change in patterns of erosion and deposition at the proposed bridge location. These risks should be taken into consideration during the design of the replacement bridge structure.

5.6 Recommendations for the design

Given the evidence of existing and potential continuing bed erosion in the reach located by Bassaleg Bridge, and the deterioration of the weir influencing the bed level, the design should account for the risk of continued scour in this reach of the River Ebbw. The following recommendations are made for the replacement bridge structure;

- Disconnection from the floodplain means overland flow is probably absent, and erosion protection should be designed to accommodate flows for large in-channel events;
- Channel bed modification should be avoided as far as possible, to maintain natural bed substrate and transport. If channel bed modification is unavoidable, the design could consider the use of flow deflectors and cross vanes to guide flow through the structure and reduce the potential for scour at any abutments (if required) and improve geomorphological diversity along the impounded reach.
- The structure should ideally be single span, and have as large an opening as feasible to minimize the potential for flow contraction and scour between abutments;
- The design of the bridge should consider the potential implications of weir failure (or future weir removal);
- Green engineering solutions could be considered in the design but may not to be suitable due to the land use constraints and expected high stream power within the river;

Figure 5.3: Historic channel position from 1892-1914 compared to present day, and the type and date of installation for nearby artificial structures.



Source: Digitised from National Library of Scotland Georeferenced Maps⁸

6 Geomorphological Impact assessment

6.1 Proposed scheme

A new bridge is proposed shortly upstream from the decommissioned bridge in Bassaleg. The new bridge will be 12.8m wide, with a clear span of 21m. By comparison, the existing bridge has a clear span of 17.1m and a width of 13.24m. The old bridge also includes a 10.85m undercut section behind the abutment on the left bank that is partially wetted, formed by historic scour. A wall will form scour protection along the right bank of the proposed bridge. The design of the proposed bridge and old decommissioned bridge is outlined in the Bassaleg Bridge Detailed Design Planning Drawings Site Layout Plan¹³.

The existing Bassaleg Bridge will be demolished following construction of the replacement structure. The extent of the existing sub-structure to be retained remains to be determined and is subject to flood risk assessment, ecological mitigation requirements, demolition feasibility, and the outcomes of this geomorphological assessment.

Scour protection will be installed across a ~50m total stretch of the River Ebbw, with bed protection 25m upstream and 25m downstream of the proposed bridge, and bank protection stretching ~48m on the right bank and ~30m on the left bank. Rip-rap will form the bed scour protection. The rip-rap size will vary from a D_{n50} of 0.75m upstream and downstream of the bridge, and a D_{n50} of 1m underneath the bridge itself. Rip-rap will be buried underneath ~60cm of bed material that will resemble baseline substrate. Bank scour protection will be provided by blockstone.

A floodwall will be installed south of the bridge near the weir to protect the local residential area. It will be set back from the river by at least 5m for a length of c.40m with backfill. It is designed to withstand up to a 1-in-200-year event.

Construction phase activities with the capacity to alter the hydromorphological regime include two cofferdams placed sequentially on either side of the proposed bridge, the methodology used to excavate the riverbed to install rip-rap, and the methodology used during the demolition of the bridge itself. At the time of writing this report, further details regarding these activities are unavailable.

6.2 Hydraulic modelling results

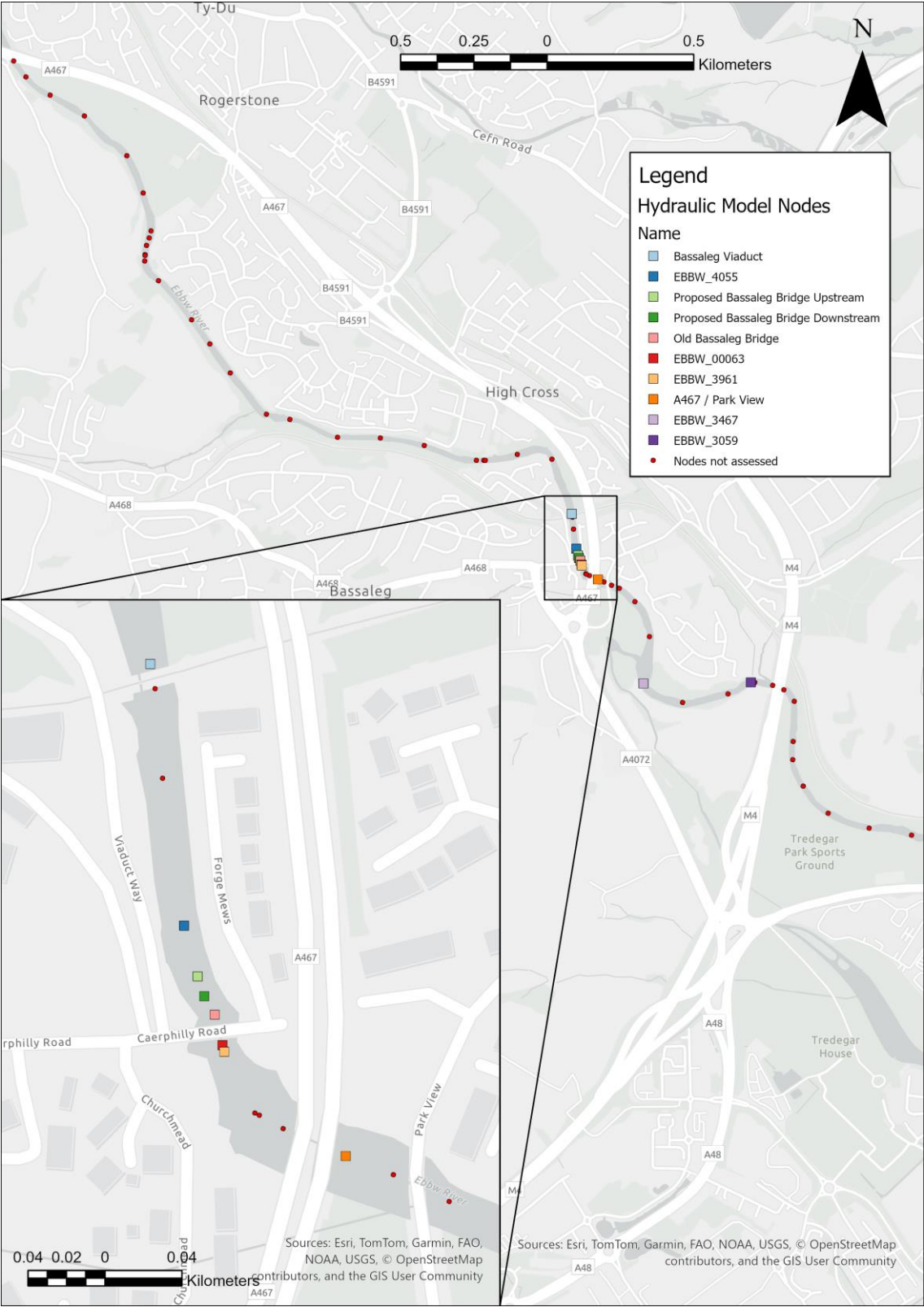
Hydraulic modelling results have been assessed to determine how changes in the river hydraulics may increase risks of erosion or deposition. The main factors considered are the magnitude of changes to water level and velocity. As identified in Section 4, various vulnerabilities exist, including active erosion downstream of the Scheme and a weir showing signs of damage. Changes to water level and flow velocity in these areas may heighten risk of erosion or weir failure, and risks to the new bridge.

Nodes from the hydraulic model were selected for assessment based on proximity to the Scheme, vulnerability of the watercourse to change (based on the walkover survey), and a potential pathway for effect. Selected nodes are outlined in Figure 5.3. The Bassaleg Viaduct node was chosen to identify upstream changes to the flow regime at the bridge. The nodes EBBW_3467 and EBBW_3059 were chosen due to the more geomorphologically sensitive nature of the area due to the presence of complex depositional features.

¹³ Bassaleg Bridge Detailed Design Planning Drawings Site Layout Plan | 100119581-MMD-XX-XX-DR-PL-1201

Hydraulic modelling results indicate that the temporary (construction phase) and permanent structure (operation phase) of the Scheme are anticipated to result in minor and localised changes to the hydraulic regime. Further analysis is presented below.

Figure 6.1: Hydraulic model nodes used for geomorphological assessment



6.2.1 Operational Phase Hydraulic Modelling

Velocity, stage (level), and flow results have been assessed for a range of flow events, comparing the Scheme scenario with the baseline. This allows assessment of the potential permanent changes with the new bridge in place and existing bridge structure removed. The results are outlined in Appendix B, specifically Table B.1, Table B.2, and Table B.3. Compared to the baseline, velocities are largely unchanged, but could be slightly higher within the immediate vicinity of the new bridge. This, combined with lower Scheme-scenario water levels in the same location, implies less constriction from the new bridge. These changes are localised to the bridge with negligible changes to both parameters further downstream. The same trend exists within the 1-in-100-year event, albeit with a greater magnitude as the drop in elevation and increase in velocity downstream from the bridge increases.

In all scenarios, the effects are highly localised to the nodes immediately surrounding the bridge, with any changes further downstream being largely negligible.

The elevation of the proposed bridge soffit varies from 21.9m on the right bank to 21.2m on the left bank. A 1-in-2-year event will not be constricted at all by the deck of the bridge itself, although events at or larger than the 1-in-100 will be.

6.2.2 Construction stage (temporary works) hydraulic model data

Velocity, stage, and flow results have been assessed, comparing the Scheme scenario during construction with the baseline. This includes proposed cofferdams to facilitate dry working areas for construction. The results of this analysis are outlined in Table B.4, Table B.5, and Table B.6. There are no expected changes during the 1-in-2-year flood event. During the 1-in-100 and 1-in-1000-year flood events, velocities will decrease, and water levels will increase as a result of the constriction caused by the cofferdam as the Ebbw will become more likely to overtop the banks. Such changes are localised in the 1-in-100-year flood event model however, and changes to velocity and water level further downstream or upstream are negligible. Very small downstream changes to level in the 1-in-1000-year flood event model, although changes are still minor and it is unlikely such an event will occur during the relatively short construction phase.

6.3 Potential geomorphology impacts

The aperture of the new bridge is larger than the existing bridge, and no abutment extend into the river itself. This represents an improvement over the existing bridge layout which does have abutments intruding into the banks, and is the most open span design possible under the site constraints. Compared to the baseline conditions, the river will be less constricted, particularly during flood events.

The impact of blockstone bank scour protection will be limited by the existence of hard banks upstream from the Scheme, and the fact that bank and bed scour protection will not extend past the existing bridge. The existing upstream bank, includes blockstone and a setback concrete wall. While the established vegetation within existing blockstone will be removed, this will be able to re-establish with time as gaps will be included in new scour protection. There will therefore be negligible long-term detriment.

The bed scour protection, including rip-rap 25m upstream and downstream of the Scheme, will present a new detriment, potentially affecting sediment continuity through the presence of large sediment. To mitigate this, rip-rap will be buried under approximately 60cm of sediment resembling the baseline conditions. It is anticipated that any changes will be minor and localised.

The bridge will cause 12.8m of shading across the River Ebbw. This is very similar to the existing bridge so just changes slightly the location of shading, with a highly localised effect on river temperature and local habitat.

The lack of water level or velocity change outside the immediate vicinity of the bridge, particularly in areas identified as vulnerable, such as eroding river banks and the damaged weir, indicates that there will be no overall increase in risk due to the new bridge. It is notable that the weir downstream from the Scheme is in a state of disrepair with a section of the downstream edge undercut and incised. Concerns exist over future deterioration of the weir, and possible risk to the integrity of the new bridge based on potential weir failure. Geomorphological analysis of the existing models has showed no change to the hydrological conditions surrounding the weir, although more detailed analysis of scour at this location would be required to eliminate risk of exacerbating the weir's degradation.

During the construction phase, cofferdams will be used to facilitate temporary channel diversion to create dry working areas, which may constrict flow and be more likely to mobilise sediment in the affected area. Similarly to the operational phase, changes are localised within the immediate vicinity of the bridge. Limited changes are identified for a 1-in-1000 year event, although the small changes and low likelihood of such as event occurring during the construction process make this a low risk.

6.4 Mitigation

The design of the new bridge should consider the geomorphological conditions of the study area outlined in this report and key standards from the Design Manual for Roads and Bridges¹⁴ and SEPA Engineering in the water environment good practice guide River Crossings¹⁵. Best practice should be adhered to including:

- Construct the bridge perpendicular to river flow;
- Ensure walls or abutments are set back from the river banks, as far as feasible;
- Minimise hard engineering where possible while balancing the need to protect essential infrastructure;
- Bury the foundations of abutments below ground/bed level;
- Scour protection cannot be entirely avoided due to the site constraints, including utilities and the necessity of maintenance access. The impact of this scour protection can nonetheless be mitigated, such as planting ledges or gaps within the blockstone to facilitate plant growth.

Best practice should be considered in collaboration with other disciplines during optioneering and design development.

¹⁴ Highways England (2020) Design Manual for Roads and Bridges LA113 Road drainage and the water environment

¹⁵ SEPA (2010) Engineering in the water environment: good practice guide – River crossings

7 Conclusions

The River Ebbw is a naturally dynamic river constrained by recent and historic development, and it also faces other pressures due to floodplain disconnection and pollution. Extensive bank protection may limit current sediment supply, which is demonstrated by some evidence of riverbed incision and bank erosion in areas where protection does not exist.

The study area is in a straightened reach where the surrounding floodplain has been built upon and disconnected from the river. The channel appears to have been narrowed and deepened, confining it over time. This acts to concentrate river energy through the confined section at the bridge crossing, over time potentially contributing to the existing bridge's instability. An open section behind the right bank abutment that was not present on the original bridge design drawings indicate active erosion in this area has occurred overtime. Scour may therefore have contributed to the bridge instability.

While the existing weir impoundment limits stream power in the reach upstream within the location of the existing and new bridge, and therefore capacity for erosion, this effect is less during high flows when the weir is likely drowned out. It is likely that such high flow events caused the scour evident under the existing bridge piers, particularly where the bridge abutment footprint was narrowing the river channel.

An analysis of the geomorphology of the area and hydraulic modelling results has found that the proposed bridge replacement's impact on the flow regime is likely to be minor and localised, especially after demolition of the existing bridge. It is mainly a 'like for like' type replacement in a slightly different location and with a wider span which should have a positive effect of constraining high flows less than the existing.

During the operational phase, changes to velocity, and depth are negligible outside of the immediate footprint of the Scheme and very minor (less than 0.2m/s change within immediate vicinity of the bridge). During the Construction phase, the use of a cofferdam to create dry working area may result in localised changes but this is considered a low risk to the river geomorphology and should be managed by consideration of the timing of works to avoid high flow periods.

A. Site Walkover Notes

A.1 Reach 1

A.1.1 Planform and flow characteristics

Reach 1 can be characterised as a medium gradient of ~ 0.0035 based on LiDAR data³ and confined by steep banks (Figure A.1). The river typology is currently passively meandering. Flow diversity was high with various glide, riffle, and pool sections, showing an overall pool-riffle type morphology (Figure A.2). Flow generally appears to have relatively high energy, compared to downstream reaches. The channel cross-section varies, average bankfull width is $\sim 20\text{m}$, wetted width $\sim 15\text{m}$, bankfull depth $\sim 3\text{m}$, and wetted depth is $\sim 0.2\text{m}$.

Figure A.1: Downstream facing view of Reach 1



Figure A.2: Side view of upstream end of Reach 1



A.1.2 Bank and substrate conditions

Bankfull depth was 1.5-2m, and the river appeared somewhat incised and disconnected from the floodplain. The bed substrate was mostly cobble-sized (Figure A.3). Bank material was variable, comprising a mixture of cobble, gravel, sand and silt (Figure A.4). Fluvial bank erosion was visible on the outside bends of meanders, with bare earth and exposed tree roots. Banks were undercut, indicating erosion through hydraulic action. Full bank erosion and lateral migration have been largely prevented by the presence of rock revetments. Banks were predominantly vegetated, with dense coverage of deciduous woodland and scrub on both sides.

Figure A.3: View of Reach 1 substrate at downstream extent.



Figure A.4: View of bank and substrate towards upstream end of Reach 1.



A.1.3 Depositional features

Depositional features included a series of unvegetated lateral bars as seen in Figure A.5 and Figure A.6. These mostly occurred on the inside bends of meanders and comprised gravel-pebble to cobble-sized clasts.

Figure A.5: Downstream view of large bar on right bank.



Figure A.6: Example of a smaller bar on left bank.



A.1.4 Riparian and in-channel vegetation

Riparian vegetation was dominated by scrubs and deciduous woodland, with many overhanging trees (Figure A.7 and Figure A.8). No 'in-channel' aquatic vegetation was observed.

Invasive species included Japanese Knotweed which predominantly populated the left bank and Himalayan Balsam which was observed on both banks.

Figure A.7: View of right bank vegetation.



Figure A.8: View of left bank vegetation.



A.1.5 Anthropogenic features

Physical modification along Reach 1 included two crossings, various outfalls, and bed/bank protection. A pedestrian footbridge (Figure A.10) is located at the upstream extent and a historic railway viaduct is observed at the downstream extent of the reach. The remains of an old, deconstructed bridge were also visible. Outfalls along the reach were likely road drainage, although this could not be confirmed. A perched outfall is shown in Figure A.9, which may indicate historic incision of the channel. Bank protection and artificial stabilisation was extensive along the reach, comprising mostly of rock revetment and gabion baskets, some of which had failed (e.g. Figure A.11). Bed protection was observed at the railway viaduct comprising concrete (Figure A.12).

Figure A.9: View of perched outfall indicating channel degradation.



Figure A.10: View of footbridge at the upstream extent.



Figure A.11: View of failed gabion baskets on left bank.



Figure A.12: View of concreted river bed below railway bridge.



A.2 Reach 2

A.2.1 Planform and flow characteristics

Reach 2 had a relatively low-gradient, with water levels controlled by a weir at the downstream extent (Figure A.13). The channel was over-deep (Figure A.14) and lacked natural flow diversity. The planform appeared artificially straight. Flow was mostly relatively slow and dominated by glides. The channel has a bankfull width of ~20m, a wetted width of ~17m, a bankfull depth of 4m and a wetted depth of 1.5m.

Figure A.13: Upstream facing view of Reach 2.



Figure A.14: Downstream facing view from upstream end of Reach 2.



A.2.2 Bank and substrate conditions

Banks were relatively high (bankfull height of ~4m) and as such the river is notably disconnected from the surrounding floodplain, which has been developed for housing. Banks were composed of a composite mixture of silt, sand, gravel and cobble (Figure A.15). There were less visible instances of erosion on this reach compared to others, largely due to the extensive bank protection and impounded flow. The notable exception to this is at the old bridge where the right bank had experienced visible scour undercutting the right pier and undercutting near a footpath at the upstream end. Substrate was less visible, with cobble and gravel where visible (Figure A.16).

Figure A.15: View of Reach 2 bank materials near eroded area.



Figure A.16: View of substrate at downstream end of Reach 2.



A.2.3 Depositional features

In contrast to other reaches, depositional features were notably absent.

A.2.4 Riparian and in-channel vegetation

Riparian vegetation comprised improved grassland and scrub on both banks with sparse tree cover. No in-channel vegetation was visible. Invasive species were prevalent along both banks (Figure A.17 and Figure A.18).

Figure A.17: View of right bank vegetation, including Himalayan Balsam.



Figure A.18: View of left bank vegetation, including Japanese Knotweed.



A.2.5 Anthropogenic features

This reach is constrained by many physical modifications, including bank protection, outfalls, bridges, and the impoundment caused by a downstream weir (Figure A.20). Natural flow diversity has been significantly reduced by the occurrence of the weir which has artificially raised the river level, causing upstream impoundment. One outfall was observed, presumably related to road drainage. The old Bassaleg Bridge shades the channel, with the right bank pier appearing to have undergone scour (Figure A.19; Figure A.21). Bank protection and stabilisation is extensive, and the river is confined by riprap and concrete walls which line both banks (Figure A.22).

Figure A.19: View of the existing Bassaleg Bridge.



Figure A.20: View of drainage outfall.



Figure A.21: View of gabion baskets beneath Bassaleg Bridge.



Figure A.22: View of blockstone reinforcing both banks



A.3 Reach 3

A.3.1 Planform and flow characteristics

Reach 3 begins at the weir where there is an artificial cascade which drops the bed level by about 1.5m. This passes into a moderate gradient section with high flow diversity (Figure A.23). The planform is straight and confined by walls, but a range of flow types were recorded including riffles, runs, and pools (Figure A.24). Due to the high walls forming the bank, bankfull depth was ~6m compared to the 0.5m wetted depth.

Figure A.23: Upstream facing view of Reach 3.



Figure A.24: Downstream facing view from upstream end of Reach 3.



A.3.2 Bank and substrate conditions

Reach 3 was entirely disconnected from the floodplain by the ~6m high artificial concrete banks that line both banks (Figure A.25). Given the artificial nature of these banks, there were no signs of bank erosion, and the river was entirely constrained. The substrate was mostly composed of cobbles, with some larger boulders.

Figure A.25: View of Reach 3 concrete banks and substrate.



A.3.3 Depositional features

Depositional features included a lateral bar and two mid-channel bars (Figure A.26; Figure A.27). These were partially vegetated and created flow diversity within the channel, forming regions of pools and riffles.

Figure A.26: Upstream view showing both mid-channel bars.



Figure A.27: Example of a smaller bar on left bank.



A.3.4 Riparian and in-channel vegetation

Given the artificial nature of the banks, no bank vegetation was observed. However, some trees were overhanging over the banks. Vegetation was also absent from the channel, with the exception of the intermittent vegetation on the bars. Large woody debris was present on some bars, creating additional flow and morphological diversity.

A.3.5 Anthropogenic features

Anthropogenic features included the weir, which has the effect of impounding flow upstream, and adding a flow diversity downstream (Figure A.28; Figure A.30). The weir appeared to be in a poor state of repair, partly undermined at the toe (Figure A.29). Other modification included the concrete embankments, which confine flow to the channel, and a large motorway bridge which shades the channel (Figure A.31). A road drainage outfall (Figure A.28) was also observed.

Figure A.28: View of drainage outfall near the weir.



Figure A.29: Upstream view of weir, including apparent erosion damage.



Figure A.30: Downstream view of weir.



Figure A.31: View of motorway bridge.



A.4 Reach 4

A.4.1 Planform and flow characteristics

Reach 4 is characterised by a wider channel with relatively high flow diversity, moderate gradient, and a return to a more sinuous planform (Figure A.32). Geomorphological features were more natural and pool riffle sequences were observed. These provide flow diversity, including runs, glides and riffles and pools (Figure A.33). Flow appeared to be relatively energy in places but at the time of survey, turbidity appeared to be low. Bankfull width is notably wider at c.34m. The wetted channel width is c.15m, bankfull depth c.1m, and wetted depth c.0.3m.

Figure A.32: Upstream facing view from upstream end of Reach 4.



Figure A.33: Downstream facing view from downstream stream end of Reach 2.



A.4.2 Bank and substrate conditions

Reach 4 appeared connected to its floodplain on the right bank, which is not substantially raised above the water level. The left bank is comparatively disconnected due to the presence of rip-rap and gabion baskets protecting a housing estate (Figure A.34). Active fluvial bank erosion was observed on the right bank on the outside bend of a meander (Figure A.35). Substrate was mostly composed of cobble-sized clasts.

Figure A.34: View of Reach 4 substrate midway through reach.



Figure A.35: Example of eroded bank at unprotected downstream area of Reach 4.



A.4.3 Depositional features

Depositional features included a large lateral bar occurring on the right bank (Figure A.36). This joins up with a confluence bar downstream, marking the confluence of a small tributary. Bars were partially vegetated with small plants (Figure A.37).

Figure A.36: Downstream view of large bar on right bank.



Figure A.37: Closer view of bar strata and vegetation.



A.4.4 Riparian and in-channel vegetation

Riparian vegetation mostly comprised scrub, with deciduous woodland lining the right bank, which extends into a large woodland area. Notably, this area had a very large amount of Himalayan balsam near the banks, as well as on the floodplain (Figure A.39). Japanese knotweed was also visible on the right bank (Figure A.38). No in-channel vegetation was visible.

Figure A.38: View of right bank vegetation, including Himalayan balsam and Japanese knotweed.



Figure A.39: View of left bank vegetation.



A.4.5 Anthropogenic features

The main modification on Reach 4 was the bank protection lining much of the left bank (Figure A.40; Figure A.41). This included rip-rap along the housing estate itself, and gabion baskets along the less populated section of the reach.

Figure A.40: View of gabion baskets further downstream on left bank.



Figure A.41: View of rip-rap on left bank.



B. Hydraulic Modelling Results

Table B.1: Results of the 1-in-2 year event model comparing the baseline and operational phase model.

Location	Peak Water Level (mAOD)		Peak Velocity (m/s)	
	Baseline	Scheme	Baseline	Scheme
Bassaleg Viaduct	21.69	21.66	1.7	1.7
EBBW_4055	20.98	20.87	2.5	2.7
Proposed Bassaleg Bridge upstream	20.86	20.68	2.6	2.9
Proposed Bassaleg Bridge	-	20.68	-	1.8
Proposed Bassaleg Bridge downstream	20.75	20.68	3.3	3.2
Old Bassaleg Bridge	20.81	20.75	2.1	2.3
EBBW_00063	20.81	20.81	2.4	2.4
EBBW_3961	20.75	20.74	2.1	2.1
A467 / Park View	19.36	19.36	1.7	1.7
EBBW_3467	17.14	17.14	2.8	2.8
EBBW_3059	15.57	15.57	1.6	1.6

Table B.2: Results of the 1-in-100 year event model comparing the baseline and operational phase model.

Location	Peak Water Level (mAOD)		Peak Velocity (m/s)	
	Baseline	Scheme	Baseline	Scheme
Bassaleg Viaduct	23.30	23.03	2.1	2.2
EBBW_4055	22.59	21.80	3.3	3.9
Proposed Bassaleg Bridge upstream	22.48	21.59	3.7	4.2
Proposed Bassaleg Bridge	-	21.59	-	1.8
Proposed Bassaleg Bridge downstream	22.24	21.50	4.0	4.6
Old Bassaleg Bridge	22.69	21.44	2.9	3.7
EBBW_00063	21.66	21.59	2.8	2.9
EBBW_3961	21.41	21.40	3.5	3.5
A467 / Park View	20.33	20.33	2.5	2.5
EBBW_3467	17.51	17.51	3.1	3.1
EBBW_3059	16.65	16.65	2.2	2.2

Table B.3: Results of the 1-in-1000 year event mode comparing the baseline and operational phase model.

Location	Peak Water Level (mAOD)		Peak Velocity (m/s)	
	Baseline	Scheme	Baseline	Scheme
Bassaleg Viaduct	24.05	24.05	2.2	2.2
EBBW_4055	23.19	23.15	3.3	3.9
Proposed Bassaleg Bridge upstream	23.14	23.27	3.7	4.2

Location	Peak Water Level (mAOD)		Peak Velocity (m/s)	
	Baseline	Scheme	Baseline	Scheme
Proposed Bassaleg Bridge	-	23.27	-	1.8
Proposed Bassaleg Bridge downstream	23.12	22.14	4.0	4.7
Old Bassaleg Bridge	23.52	22.33	2.9	3.8
EBBW_00063	22.31	22.42	2.8	3.0
EBBW_3961	22.05	22.12	3.5	3.7
A467 / Park View	20.52	20.55	3.3	3.5
EBBW_3467	18.22	18.23	3.1	3.1
EBBW_3059	17.70	17.68	2.5	2.6

Table B.4: Results of the 1-in-2 year event model comparing the baseline and temporary construction stage model.

Location	Peak Water Level (mAOD)		Peak Velocity (m/s)	
	Baseline	Construction	Baseline	Construction
Bassaleg Viaduct	21.69	21.67	1.7	1.7
EBBW_4055	20.98	20.88	2.5	2.7
Proposed Bassaleg Bridge upstream	20.86	20.70	2.6	2.9
Proposed Bassaleg Bridge	-	20.70	-	1.8
Proposed Bassaleg Bridge downstream	20.75	20.69	3.3	3.2
Old Bassaleg Bridge	20.81	20.81	2.1	2.1
EBBW_00063	20.81	20.81	2.4	2.4
EBBW_3961	20.75	20.75	2.1	2.1
A467 / Park View	19.36	19.36	1.7	1.7
EBBW_3467	17.14	17.14	2.8	2.8
EBBW_3059	15.57	15.57	1.6	1.6

Table B.5: Results of the 1-in-100 year event model comparing the baseline and construction phase model.

Location	Peak Water Level (mAOD)		Peak Velocity (m/s)	
	Baseline	Construction	Baseline	Construction
Bassaleg Viaduct	23.30	23.48	2.1	2.2
EBBW_4055	22.59	23.02	3.3	3.4
Proposed Bassaleg Bridge upstream	22.48	22.98	3.7	3.8
Proposed Bassaleg Bridge	-	22.98	-	1.8
Proposed Bassaleg Bridge downstream	22.41	22.39	4.0	4.1
Old Bassaleg Bridge	22.69	22.67	2.9	2.9
EBBW_00063	21.66	21.78	2.8	2.7
EBBW_3961	21.41	21.54	3.4	3.3
A467 / Park View	20.33	20.33	2.5	2.5
EBBW_3467	17.51	17.51	3.1	3.1
EBBW_3059	16.65	16.65	2.2	2.2

Table B.6: Results of the 1-in-1000 year event model comparing the baseline and construction phase model.

Location	Peak Water Level (mAOD)		Peak Velocity (m/s)	
	Baseline	Construction	Baseline	Construction
Bassaleg Viaduct	24.05	24.07	2.2	2.2
EBBW_4055	23.19	23.16	3.3	3.4
Proposed Bassaleg Bridge upstream	23.14	23.71	3.7	3.8
Proposed Bassaleg Bridge	-	23.71	-	1.8
Proposed Bassaleg Bridge downstream	23.12	22.95	4.0	4.1
Old Bassaleg Bridge	23.52	23.19	2.9	2.9
EBBW_00063	22.31	22.29	2.8	2.7
EBBW_3961	22.05	22.10	3.5	3.3
A467 / Park View	20.52	20.49	3.3	3.0
EBBW_3467	18.22	18.19	3.1	3.1
EBBW_3059	17.70	17.75	2.5	2.4

