Contents

8 WATER

8.1 INTRODUCTION

The chapter assesses and evaluates the proposed Limerick City Greenway (UL to NTP) concerning the hydrological and hydrogeological environment. Refer to Figure 8.1. The impact of the Limerick City Greenway (UL to NTP) is assessed in this chapter against the baseline conditions and character of the Study Area. Mitigation measures are provided to minimise or eliminate any potential negative effects on water and the residual effects are assessed. Potential for cumulative effects on the hydrological and hydrogeological environment is also assessed in this chapter.

A detailed description of the proposed development and construction activities is provided in Chapter 4: Description of Proposed Development. Impacts on Aquatic Ecology are assessed in Chapter 6: Biodiversity.

The Limerick City Greenway (UL to NTP) has an indefinite operational duration; therefore, it is not considered necessary to assess the impacts of decommissioning.

The Study Area, for the purposes of this chapter, covers an area of approximately 5.8km^2 and includes UL Campus, the National Technology Park (NTP), and the south bank of the Lower River Shannon. The main water body present is the Lower River Shannon which traverses through the centre of the Study Area. The River Groody is present at the western end of the area and the River Mulkear is at the eastern end. A small section of the Blackwater is present to the north of the Study Area near the Cappavilla UL Campus.

The scope of this chapter entails the following:

- Description of the hydrological, hydrogeological and water quality setting relevant to the proposed works;
- Assessment of the 'do nothing' scenario
- Description and evaluation of the likely impacts (on the water environment) of the development in terms of construction and operational phases including the character, magnitude and duration of such impacts;
- Description and development of proposed mitigation measures to minimise any potential impacts;
- Description of the residual impacts after mitigation; and
- Description of impact interactions and cumulative impacts.

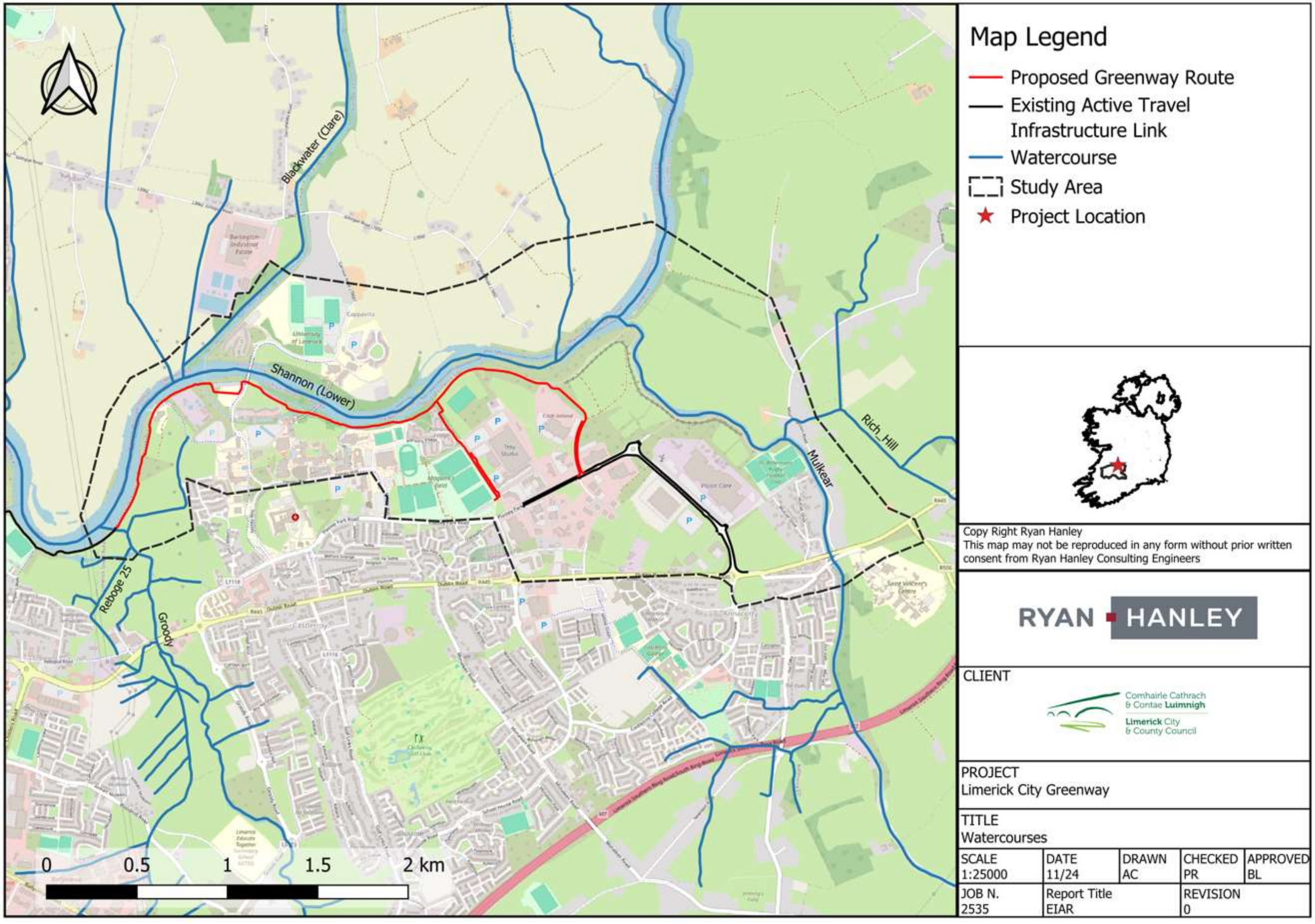


Figure 8-1: Study Area

8.2 METHODOLOGY

8.2.1 Literature Review

A desk study of relevant data was conducted in July/August 2024. The following documentation and sources were reviewed:

- The Water Framework Directive
- National River Basin Management Plan (2022 – 2027)
- Ordnance Survey Ireland (OSI) mapping – www.osi.ie
- Geological Survey of Ireland (GSI) – www.gsi.ie
- The Environmental Protection Agency (EPA) - a data request was submitted for any relevant water quality data within the Lower Shannon catchment, limited to the last ten years. An online search of the EPA databases was conducted through the following websites:
    - www.catchments.ie for all catchment data
    - water quality database www.epa.ie
- Met Éireann meteorological data - www.met.ie;
- The Floods Directive (2007/60/DC)
- OPW hydrological data:
    - www.floodinfo.ie;
    - Real time data - www.waterlevel.ie;
    - Archived data - www.opw.ie/hydro-data;
- Limerick City and County Council:
    - Limerick Development Plan 2022-2028
    - Planning Register;
    - Water Services – Abstractions, Discharges & Supply Schemes;
- National Parks and Wildlife Services (NPWS):
    - Designated Areas Mapping;
    - Site Synopsis Reports;
- National Biodiversity Data Centre (NBDC) - https://maps.biodiversityireland.ie
- Well card data compiled by the Geological Survey of Ireland (GSI).

8.2.2 Relevant Legislation

The EIAR is prepared in accordance with the requirements of European Union (EU) Directive 2011/92/EU on the assessment of the effects of projects on the environment (the 'EIA Directive') as amended by Directive 2014/52/EU. The key objective of the amendment was to protect water resources and prevent a deterioration of water in compliance with the EU Water Framework Directive (2000/60/EC).

The WFD requires EU member states to manage their water resources on an integrated basis to achieve at least '*good*' ecological status. In Ireland this is achieved through the River Basin Management Plan for Ireland 2022-2027 (DoHGLP, 2024; 'the RBMP'). The RBMP outlines all the actions required to improve the ecological status, with county councils and Uisce Éireann (UÉ) playing an important role in the implementation of the plan.

WFD characterisation, monitoring and status assessment programmes are governed by three Regulations:

- Water Policy Regulations 2003 - 2014;
- European Communities Environmental Objectives (Surface Waters) Regulations 2009 - 2019 which provide an extensive suite of environmental standards for Irish surface waters; and
- European Communities Environmental Objectives (Groundwater) Regulations 2010 – 2016 which provide groundwater quality standards and threshold values for groundwater characterisation and protection against deterioration.

The WFD's main objectives are:

- To protect, enhance and restore the status of all bodies of water and to prevent their further deterioration;
- To achieve at least 'good status' by 2027 (with some limited exemptions);
- To promote sustainable use of water;
- To reduce the pollution of water by particularly hazardous 'priority' substances; and
- To lessen the effects of flooding and drought.

This project will contribute to the achievement of the WFD as cycling is an environmentally friendly activity and encourages a sustainable interaction with the water environment without placing direct pressure on this resource. The proposed Greenway will also support natural vegetation along the River Shannon and reduce sedimentation which will prevent a deterioration in water quality.

The requirements of the following legislation are complied with:

- Planning and Development Acts, 2000 (as amended).
- Planning and Development Regulations, 2001 (as amended).
- S.I. No 296/2018: European Union (Planning and Development) (Environmental Impact Assessment) Regulations 2018 which transposes the provisions of the EIA Directive as amended by the Directive 2014/52/EU into Irish Law.
- S.I. No. 94/1997 European Communities (Natural Habitats) Regulations, resulting from EU Directives 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (the Habitats Directive) and 79/409/EEC on the conservation of wild birds (the Birds Directive);
- S.I. No. 272/2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009, as amended, and S.I. No. 722/2003 European Communities (Water Policy) Regulations, as amended, which implement EU Water Framework Directive (2000/60/EC) and provide for the implementation of '*daughter*' Groundwater Directive (2006/118/EC).

Other relevant Acts include:

- Quality of Salmonid Waters Regulations (S.I No 293 of 1988) (Although this has been superseded by the WFD).

This chapter was also informed in accordance with the following guidelines:

- Guidelines on the Information to be contained in Environmental Impact Assessment Reports, EPA, 2022;
- Inland Fisheries Ireland (2016): Guidelines on Protection of Fisheries during Construction Works in and Adjacent to Watercourses.
- CIRIA (Construction Industry Research and Information Association) Guidance on 'Control of Water Pollution from Linear Construction Projects' (CIRIA Report No. C648, 2006).
- CIRIA (Construction Industry Research and Information Association) Control of Water Pollution from Construction sites - Guidance for Consultants and Contractors. CIRIA C532. London, 2001.
- National Roads Authority (2008) Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes
- Advice Notes for Preparing Environmental Impact Statements, Draft September 2015.

8.2.3 Status of Water Bodies

'Status' is a descriptor term that incorporates ecological, physio-chemical and hydromorphological data and facilitates catchment comparisons on an EU scale and is assessed by the EPA. Biological information is provided in the form of Q values. Q values are biotic indices used to express ecological water quality and are based on changes in the macro invertebrate communities of riffle areas brought about by organic pollution. Q1 indicates a seriously polluted water body and Q5 indicates unpolluted water of high quality. A value of Q3 indicates moderately polluted water. These Q value ratings are shown in **Table 8:1**.

The Ecological Quality Ratio (EQR) represents the comparison between the observed biological parameter values (such as Q-values) for a surface water body and the values expected under pristine or reference conditions for that water type. The macroinvertebrate EQR is used to classify sites based on their ecological quality, as required by river basin management planning under the WFD. The EQR is a numerical score ranging from 0 to 1, where values near 1 indicate high ecological status, and values near 0 indicate poor status. This system allows consistent comparison of water quality across the European Union, as each member state assigns EQR values to ecological status categories: 'High', 'Good', 'Moderate', 'Poor', and 'Bad'. According to the WFD, all surface waters must achieve or be maintained at least at 'Good Ecological Status' (Q4) within specific timeframes outlined in the River Basin Management Plans (RBMPs), and high-status waters (Q4-5 and Q5) must not deteriorate.

Table 8:1 Q Value Classification

Quality Ratings	EQR*	Pollution Status		Ecological Status
Q5	1.0	Unpolluted	Good	**High**

Quality Ratings	EQR*	Pollution Status		Ecological Status
Q4-5	0.9	Unpolluted	Fair to Good	
Q4	0.8	Unpolluted	Fair	**Good**
Q3-4	0.7	Slightly Polluted	Doubtful to Fair	**Moderate**
Q3	0.6	Moderately Polluted	Doubtful	**Poor**
Q2-3	0.5	Moderately Polluted	Poor to Doubtful	
Q2	0.4	Seriously Polluted	Poor	**Bad**
Q1, Q1-2	<0.3	Seriously Polluted	Bad to Poor	

*Ecological Quality Ratio

In addition to the status assessment (conducted every three years at EPA monitoring stations), each waterbody is classified into different risk categories based on whether it is likely to meet the WFD objectives by 2027. Risk is determined by combining monitoring data, catchment pressures, and information on implemented protection measures.

The three risk categories are:

- Waterbodies At Risk of not meeting WFD objectives.
- Waterbodies Not at Risk, meaning they are currently meeting WFD objectives.
- Waterbodies classified as Review, where additional information is needed to assess their risk status.

The receiving water body associated with the proposed Greenway, which could potentially be impacted upon is the Shannon (Lower)_060' (IE_SH_25S012600).

8.2.4 Consultations

A scoping document was prepared and issued to the relevant stakeholders (incl. Limerick County Council., EPA, NPWS and IFI) and any responses received are included in Chapter 2 of the EIAR. Consideration has been given to these responses in the preparation of this Chapter of the EIAR.

8.2.5 Surface Water Chemistry

River Shannon Data Review

A review of available River Shannon EPA water chemistry data was conducted for the relevant study area. Physico-chemical parameters were interpreted with respect to legally binding environmental quality national standards (EQSs) under Surface Water Regulations (S.I. 77 of 2019) to support the achievement of high and good ecological status, as set out in Table 8:2.

Table 8:2: Physio-chemical boundary values for status in Irish Rivers (S.I. 77 of 2019)

Parameter	High Status	Good Status
Ortho P (MRP) (mg P/l)	≤ 0.025 (mean); ≤ 0.045 (95%ile)	≤ 0.035 (mean); ≤ 0.075 (95%ile)
Ammonia (mg N/l)	≤ 0.040 (mean); ≤ 0.090 (95%ile)	≤ 0.065 (mean); ≤ 0.140 (95%ile)
BOD (mg O_2/l)	≤ 1.3 (mean) or ≤ 2.2 (95%ile)	≤ 1.5 (mean) or ≤ 2.6 (95%ile)
Dissolved Oxygen (% sat.)		80 -120%

8.2.6 Hydraulic Modelling

The hydraulic modelling data contained within this chapter relating to flood levels on the River Shannon was accessed via the OPW flood data Web Mapping Service (WMS).

8.2.7 Assessment of Effects Criteria

This assessment identifies and describes likely significant effects of the proposed development based on the sensitivity of the receptors. Using the above methodologies, the sensitivities of water environment receptors were analysed using a combination of desk and baseline field studies. Levels of hydrological and hydrogeological receptor importance are then defined using criteria in Table 8:3 and Table 8:4, respectively.

The likely effects are described as per EPA (2022) concerning their quality (positive, neutral or negative), significance (imperceptible to profound), extent/magnitude, context (e.g., geographical), probability (likely or unlikely), duration (momentary to permanent), frequency and reversibility. The impact assessment descriptors used in this chapter are shown in Table 8:5 and Table 8:6 (from EPA 2022).

Table 8:3: Criteria for rating Site Importance for Hydrological Attributes at EIA stage (NRA, 2008)

Importance	Criteria	Typical Example
Extremely High	Attribute has a high quality or value on an international scale	▪ River, wetland or surface water body ecosystem protected by EU legislation, e.g. '*European sites*' designated under the Habitats Regulations or '*Salmonid waters*' designated pursuant to the European Communities (Quality of Salmonid Waters) Regulations, 1988.
Very High	Attribute has a high quality or value on a regional or national scale	▪ River, wetland or surface water body ecosystem protected by national legislation – NHA status. ▪ Regionally important potable water source supplying >2500 homes. ▪ Quality Class A (Biotic Index Q4, Q5). ▪ Flood plain protecting more than 50 residential or commercial properties from flooding. ▪ Nationally important amenity site for a wide range of leisure activities.

Importance	Criteria	Typical Example
High	Attribute has a high quality or value on a local scale	▪ Salmon fishery ▪ Locally important potable water source supplying >1000 homes. ▪ Quality Class B (Biotic Index Q3-4). ▪ Flood plain protecting between 5 and 50 residential or commercial properties from flooding.
Medium	Attribute has a medium quality or value on a local scale	▪ Coarse fishery. ▪ Local potable water source supplying >50 homes Quality Class C (Biotic Index Q3, Q2-3). ▪ Flood plain protecting between 1 and 5 residential or commercial properties from flooding.
Low	Attribute has a low quality or value on a local scale	▪ Locally important amenity site for small range of leisure activities. ▪ Local potable water source supplying <50 homes. ▪ Quality Class D (Biotic Index Q2, Q1) Flood plain protecting 1 residential or commercial property from flooding. ▪ Amenity site used by small numbers of local people.

Table 8:4: Criteria for rating Site Importance for Hydrogeological Attributes at EIA stage (NRA, 2008)

Importance	Criteria	Typical Example
Extremely High	Attribute has a high quality or value on an international scale	▪ Groundwater supporting river, wetland or surface water body ecosystem protected by EU legislation, e.g. SAC or SPA status.
Very High	Attribute has a high quality or value on a regional or national scale	▪ Regionally Important Aquifer with multiple wellfields. ▪ Groundwater supports river, wetland or surface water body ecosystem protected by national legislation - NHA status. ▪ Regionally important potable water source supplying >2500 homes Inner source protection area for regionally important water source.
High	Attribute has a high quality or value on a local scale	▪ Regionally Important Aquifer Groundwater (provides large proportion of baseflow to local rivers). ▪ Locally important potable water source supplying >1000 homes. ▪ Outer source protection area for regionally important water source. ▪ Inner source protection area for locally important water source.
Medium	Attribute has a medium quality or value on a local scale	▪ Locally Important Aquifer. ▪ Potable water source supplying >50 homes. ▪ Outer source protection area for locally important water source.

Importance	Criteria	Typical Example
Low	Attribute has a low quality or value on a local scale	▪ Poor Bedrock Aquifer ▪ Potable water source supplying <50 homes.

Table 8:5: Ecological Impact Duration Criteria (from EPA, 2022)

Significance of Effect	Criteria
Neutral	No impact
Imperceptible	An impact capable of measurement but without noticeable consequences
Not Significant Effects	An impact which causes noticeable changes in the character of environment but without significant consequences
Slight Effects	An impact which causes noticeable changes in the character of the environment without affecting its sensitivities
Moderate Effects	An impact that alters the character of the environment in a manner that is consistent with existing and emerging trends
Significant Effects	An impact which, by its character, magnitude, duration or intensity significantly alters a sensitive aspect of the environment
Very Significant Effects	An impact which, by its character, magnitude, duration or intensity significantly alters most of a sensitive aspect of the environment

Table 8:6: Ecological Impact Duration Criteria (from EPA, 2022)

Impact Duration	Criteria
Momentary Effects	Effects lasting from seconds to minutes
Brief Effects	Effects lasting less than a day
Temporary Effects	Effects lasting less than a year
Short-term Effects	Effects lasting one to seven years
Medium-term Effects	Effects lasting seven to fifteen years
Long-term Effects	Effects lasting fifteen to sixty years
Permanent Effects	Effects lasting over sixty years
Reversible Effects	Effects from which spontaneous recovery is possible within a reasonable timescale or which may be counteracted by mitigation.
Irreversible Effects	Effects from which recovery is not possible within a reasonable timescale or there is no reasonable chance of action being taken to reverse it.

8.3 EXISTING ENVIRONMENT

8.3.1 Physical Environment

The proposed 4.483km long route of the Greenway is located along the River Shannon, in Castletroy, Co. Limerick. The proposed route follows the south bank of the River Shannon, from the bridge on the Groody River, west from UL Boat House (R 657834.53, 560288.70) passing Troy Studio after which turns south (R 658627.17, 562678.42) to reach McLoughlan Road and joins Plassey Park Road. A separate spur turns south at Kilmurray Student Village and continues south along University Road until it joins with Plassey Park Road.

The route runs alongside the River Shannon for approximately 3 km, before turning south towards McLoughlan Road.

The reaches of the River Shannon that follow the Greenway route are typical of an urbanised river catchment. Riparian and marginal habitats on either side are dominated by dense weed and low shrub cover, with a sporadic tree canopy throughout. There is evidence of common invasive non-native plant species (INNS), including Himalayan balsam (*Impatiens glandulifera*) and giant hogweed (*Heracleum mantegazzianum*). Land use is mixed, with agricultural (livestock), amenity and green urban areas, though some of this has given way to construction and transitional woodland (CLMS, 2018).

There are multiple drains that flow either directly into the watercourse or terminate in the riverbank along the surveyed reach. During the walkover surveys, some were discharging grey water, indicative of urban run-off and/ or wastewater, suggesting that there may be point-source pollution and water quality issues in this area.

8.3.1.1 Catchment Description

The Study Area is within Hydrometric Area 25D (Lower Shannon catchment), that consists of the lower south-east of the catchment (Figure 8-2). The Shannon river basin district (RBD) is the largest in Ireland and drains a catchment of approximately 11,600 km^2 before entering the sea via the Shannon estuary. The Shannon RBD is the full River Shannon catchment including Shannon Estuary.

The zone of influence (ZoI) of the proposed development on the water environment is primarily limited to localised area within the sub basin in which the proposed development is located, specifically Shannon (Lower) _060 (RWB). The downstream finish of the Shannon_060 becomes tidal. The northern shoreline of the River Shannon falls under sub-catchment Shannon (Lower)_100.

Throughout the Study Area the River Shannon is principally a deep channel with braided islands and exhibiting an increased degree of sinuosity downstream as it passes Limerick City towards the Shannon Estuary. Much of the River Shannon catchment is rural, however, there are six significant urban centres within the RBD comprising Limerick City (59 km^2), Ennis (25 km^2), Tralee (22 km^2), Mullingar (22 km^2), Athlone (11 km^2) and Tullamore (30 km^2). The River Shannon flows through an area of unsorted alluvial material (glacial till) assumed to consist of mixed sediment-size sand and gravel. There is some evidence of mixed marine sediments extending up the Shannon Valley. The general slope of the River Shannon through the proposed Greenway is 1.5 m/km. The groundwater body associated with the proposed Greenway is Limerick City East (IE_SH_G_138).

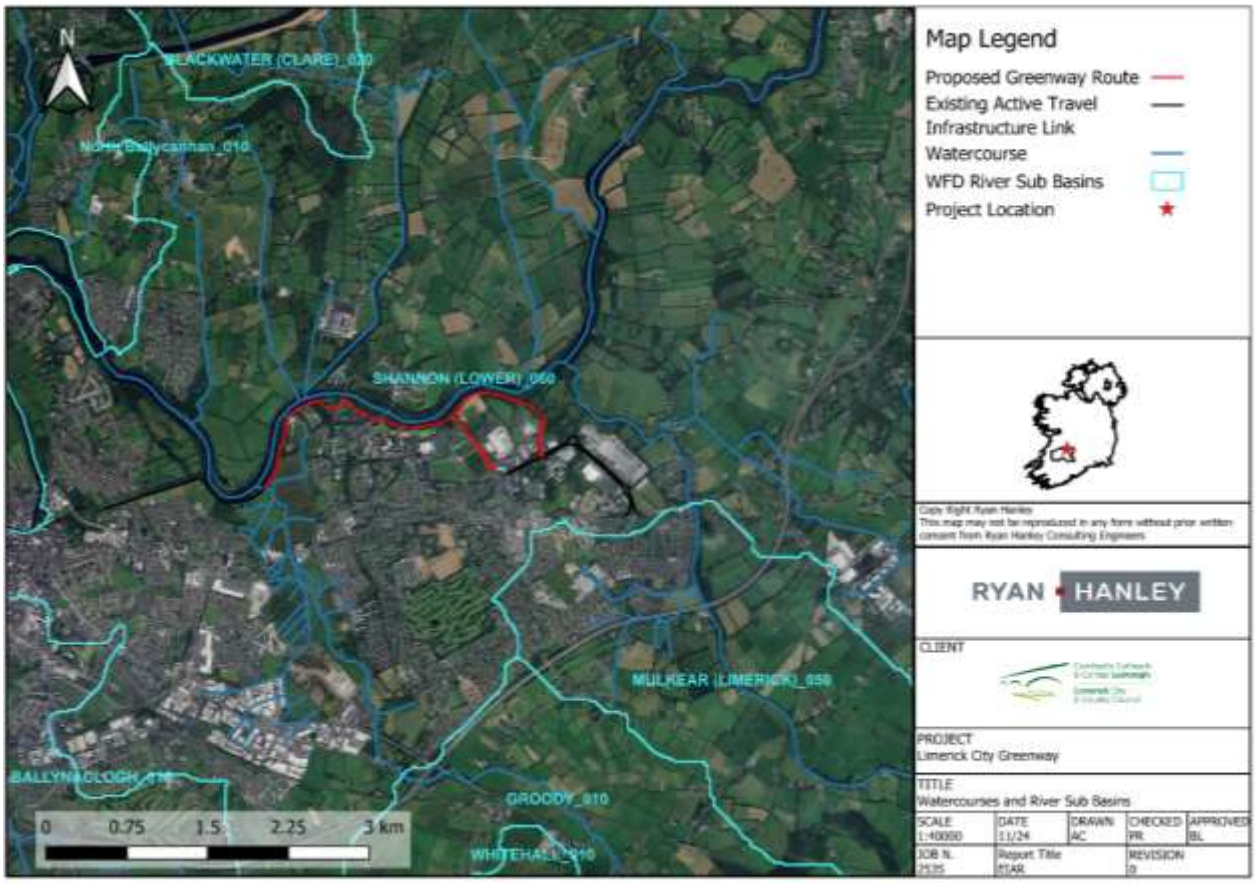


Figure 8-2: Relevant River Water Bodies in the ZoI

In summary the proposed Greenway consists of glacial till deposits with some minor estuarine deposits and is characterized by mixed terrain soils consisting of poorly drained mineral soils, well-drained mineral soils and gleys which occasionally contain water. The bedrock geology is limestone.

Grazing may be a notable pressure for both rivers. Channelisation and embankment are present and may impact both hydrological and morphological conditions, and therefore alter habitat within the waterbody. River water quality within the entire sub-catchment has been described as moderate-good.

Geology and subsoils are assessed in Chapter 7, the Study Area is underlain by two main bedrock units: Dinantian Visean Limestone Formation (Undifferentiated) and Dinantian Rathkeale Formation. The GSI Online Database indicates that subsoils within and in the vicinity of the Study Area comprise tills, alluvium minerals, marine/estuarine sediments and areas of made ground.

The Works Area (described in Chapter 4) is characterized as a locally important bedrock aquifer that is moderately productive in local zones. There are no records of groundwater abstractions being used for potable supply.

In line with Step 3 of the Institute of Geologists of Ireland (IGI) guidelines, the baseline information indicates the hydrogeological environment is determined to be:

- **Type A - Passive geological/hydrogeological environments e.g. areas of thick low**

permeability subsoil, areas underlain by poor aquifers, recharge areas, and historically stable geological environments.

This conclusion is based on the area being underlain by two main groundwater systems (Appendix 8A), both locally important. There is a small section to the east of the Study Area with a third groundwater body but the surface occupied by the Study Area is not significant. One of the groundwater systems is described as moderately productive with bedrock composed of undifferentiated Visean Limestones, dark muddy limestone & shaly mudstone. The Visean Limestone bedrock extends to a depth of <20 m and covers a greater part of the Limerick area. The other bedrock aquifer is comprised of Volcaniclastic rock and is described as only moderately productive in local zones. Recharge potential of both areas are in the moderate - high percentages and the recharge coefficient not suitable to provide adequate recharge of ground water bodies. The study area covers several groundwater vulnerability codes ranging from extreme to moderate.

A range of activities can potentially interact and impact with the hydrogeological environment:

- earthworks;
- storage/ transmission of leachable and /or hazardous materials;
- discharges to ground; and
- excavation of materials above and below the water table.

8.3.1.2 Hydrological Cycle

The River Shannon, which originates in the slopes of Cuilcagh Mountain in Co. Cavan, is susceptible to intense rainfall and as a result is prone to flooding.

There are several Met Éireann Rainfall stations within the Shannon catchment, however only Mount Dillion (Co. Roscommon), Mullingar (Co. Westmeath) and Gurteen (Co Tipperary) have long-term rainfall averages for the period 1981-2010, which are 1047.1 mm, 970.9 mm and 948.2 mm respectively. Other gauges in the catchment have been discontinued or have been installed post 2008. Figure 8-3 indicates the annual rainfall recorded at each station.

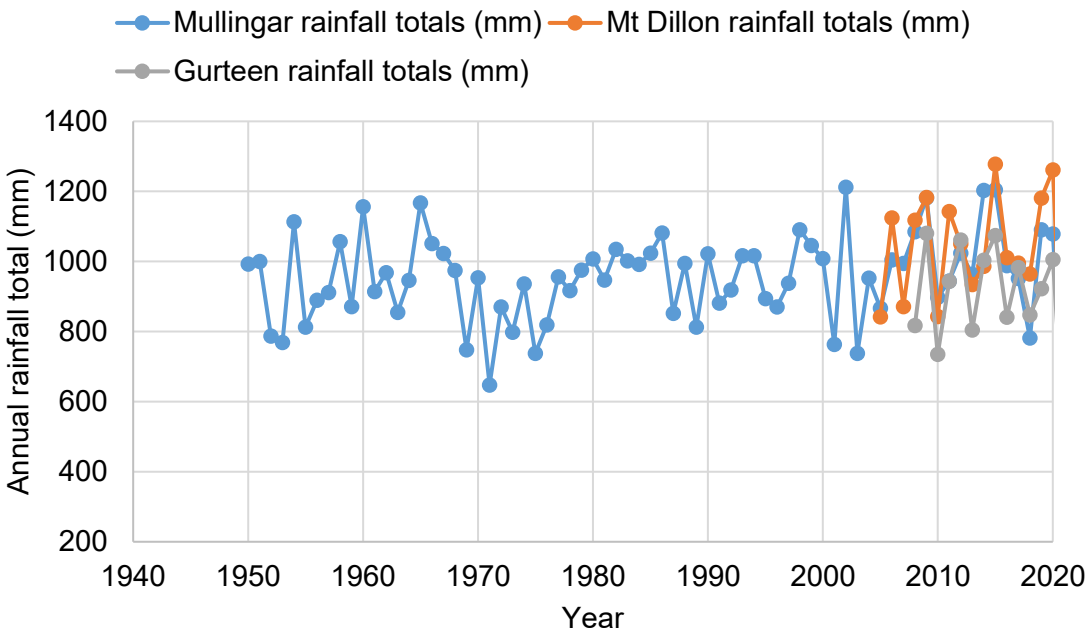


Figure 8-3 Annual Rainfall

The closest synoptic station where air temperature and average potential evapotranspiration (PE) are recorded is at Shannon Airport, Co. Clare, located approximately 20 km west of the Lower Shannon sub-catchment. The long-term average annual PE for this station is 562.6 mm/ year. The effective annual average rainfall (ER) represents the water available for runoff or groundwater recharge and is the rainfall less the actual evapotranspiration. The ER for the proposed Greenway is ~524.6 mm as reported by GSI (www.gsi.ie)

The OPW have a water level gauge at Balls Bridge (25061) on a branch of the Park Canal which joins the east and west side of Limerick city on a large meander on the River Shannon, the gauge is approximately 6.5 km downstream from the proposed Greenway. Water level measurements Above Ordnance Datum (AOD) have been recorded since 2002 at this location (*Figure 8-4*).

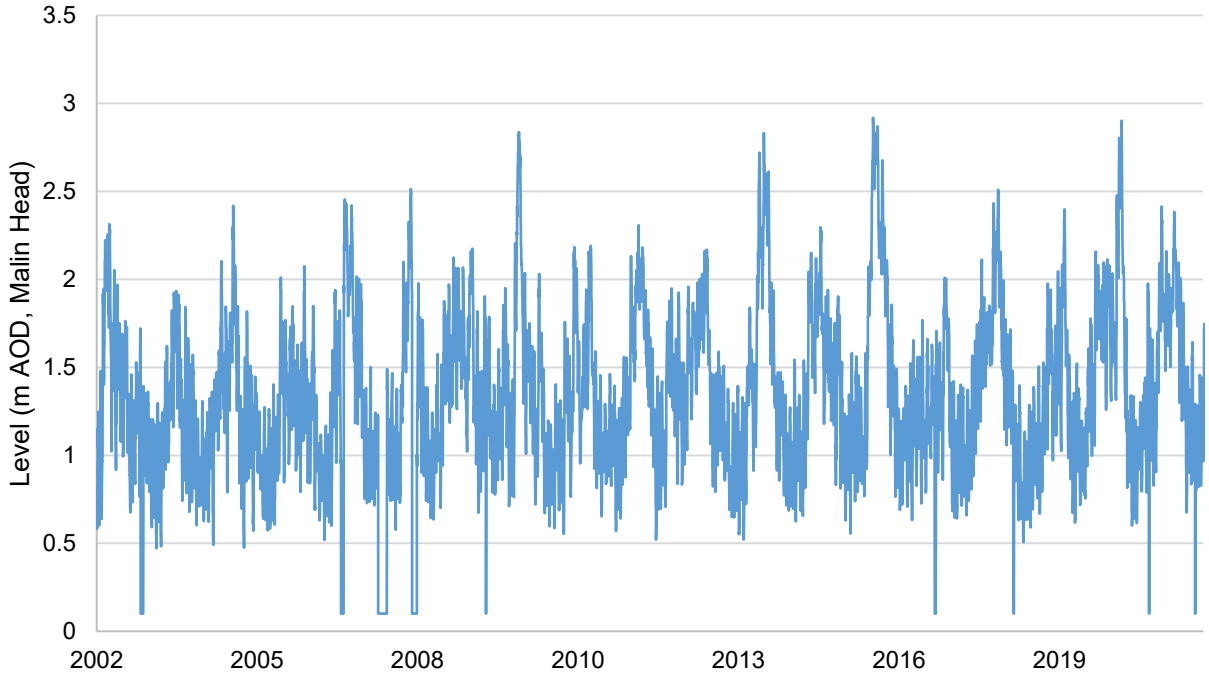


***Figure 8-4** Daily average Balls Bridge water level (m AOD)*

Furthermore, the OPW maintain a water level gauge at Limerick Dock (24063) approximately 10 km downstream from the proposed Greenway; the gauge has been recording for two years (Figure 8.5).

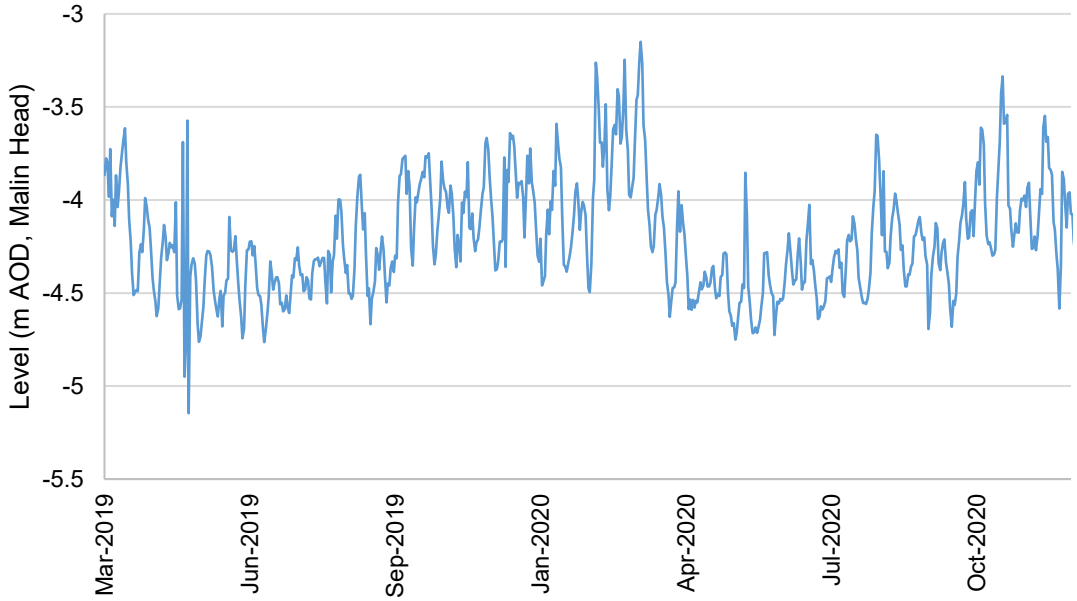


Figure 8-5 Limerick Dock water level

8.3.1.3 Drainage and Flooding

A Flood Risk Assessment was prepared for this project. Maintenance of this drainage infrastructure by LCCC will be required.

A justification test for the development in accordance with the Flood Risk Management Guidelines, further confirmed that the proposed development is appropriate albeit with mitigations. The Greenway track should be constructed to be water compatible, i.e. one which is resistant to damage caused by flooding and prolonged inundation, e.g. sealed surface, appropriate drainage etc.

Flood Mapping developed by the OPW CFRAM programme confirms that appreciable lengths of the proposed Greenway are in Flood Zone A (2.36km) and Flood Zone B (2.77km) associated with the River Shannon and its tributaries scheme floodplains.

The proposed scheme, being an "Amenity open space, outdoor sports and recreation" facility, is classed as a Water Compatible development in the OPW Planning System and Flood Risk management Guidelines, and therefore is an appropriate development for both Flood Zone A and B.

Much of the River Shannon floodplain displays evidence of past glaciation where flood water flows around topography to form floodplain connectivity which is not evident under normal flows. At the upstream extent the Shannon floodplain is approximately 1.5 km wide, narrowing to 500 m at the downstream extent. The Shannon displays a slow response to rainfall, so flood events are generally due to long-sustained periods of heavy rainfall, rather than short duration intense rainfall events which may cause flash flooding in more responsive catchments.

The presence of Lough Ree, which has a surface area of 105 km^2 and catchment area of 4,530 km^2, within the upper Shannon is another significant feature which reduces peak flow response to rainfall. There is a history of flood risk associated with lower Shannon close to the proposed Greenway route, and a summary is provided in Table 8.7.

Table 8.7 *Significant flood events near the proposed Greenway on the River Shannon*

Date	River	Description
December 1954	Shannon	Large flood events during Christmas 1954, much of rural Shannon catchment was affected, farmland inundated (Irish Independent, 1954).
February 1990	Shannon	Significant flooding, many residents evacuated in and around Limerick, high flow in the Shannon and high tides. (Limerick Chronicle, 1990)
December 1999	-	Reported widespread European flooding; in Ireland worst hit areas included Limerick but no specifics provided (Irish Independent, 1999)
December 2006	Shannon	No additional information available, University of Limerick (UL) and surrounding area shown to be inundated on OPW archived aerial imagery. Limerick and Ballyvolane significantly flooded.
November 2009	-	Significant flooding understood to be as severe as the 1990 flood, UL impacted, Limerick significantly impacted, aerial photographs available within OPW archive show fields around UL significantly inundated, aerial imagery available on OPW archives. Castletroy area (around UL) also reported as being significantly inundated during flood event.

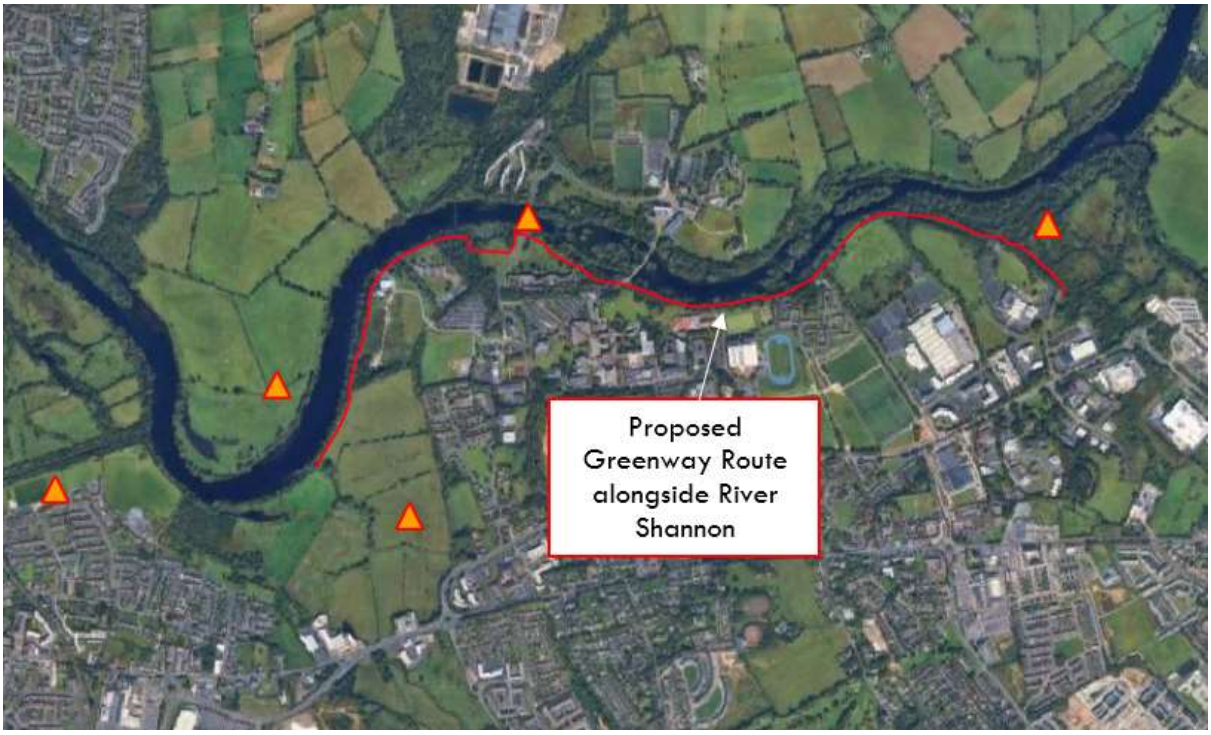


***Figure 8-6*: Past Flood Events OPW database (www.floodinfo.ie)**

inundation, e.g. sealed surface, appropriate drainage etc.

***Figure 8-7*:: November 2009 River Shannon Flood Event at UL campus in Co. Limerick on left hand side, with UL campus in Co. Clare on right hand side of figure, OPW database (www.floodinfo.ie)**

***Figure 8-8*:: Sections of Greenway at Flood Risk (1 in 100 or 1% AEP)**

Modelled flood levels on the River Shannon are available via the OPW flood data Web Mapping Service (WMS); there are nine nodes adjacent to the River Shannon. Elevations along the Greenway adjacent to the River Shannon have been sampled from OPW light detecting and ranging (LiDAR) digital terrain model

(DTM) data. These have been compared with the modelled maximum flood levels for the 50%, 5%, 2%, 1%, 0.5% and 0.1% Annual Exceedance Probability events. Refer to Figure 8-6. The modelled flood levels indicate that much of the existing ground levels of the proposed Greenway are inundated during a 5% AEP (AKA 20-year) flood event; the area inundated during this event type is typically considered a functional floodplain.

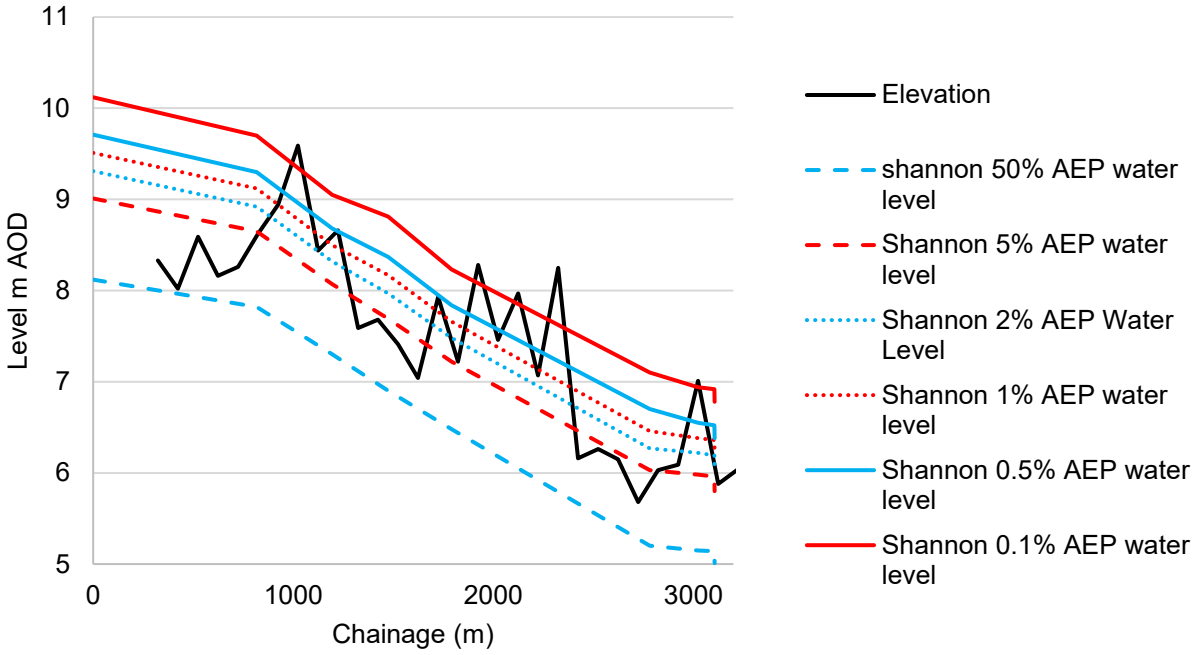


Figure 8-9: OPW modelled water levels along the Shannon overlain with levels sampled from the OPW LiDAR data DTM along the Greenway extent

Reviewing the Flood Risk Assessment and the OPW flood maps for present day fluvial flood risk and high end future climate change scenario fluvial flood risk, which are reproduced in Figure 8-10 to Figure 8-16, it is evident that parts of the proposed Greenway have a high probability of flooding, for the present day low probability event and future events. In the present day 1:10 year event (refer to Figure 8-7) the route between the River Groody bridge and the UL Boat House is predicted to flood but anecdotal evidence from local users of the existing path in this location has confirmed that the existing path can be used during high river levels because it is elevated.

This prediction for flooding is to be expected due to the proximity of the proposed Greenway to the River Shannon which has known historic flooding. As probability decreases severity increases and the flood extent is shown to swell for the lower probability events. When considering the impact of climate change i.e. the *high end future scenario*, the proposed Greenway is flooded and the surrounding floodplain are inundated to a greater extent than the present day scenario.

The maps below contain Irish Public Sector Information licensed under a Creative Commons Attribution 4.0 International (CC BY 4.0) license (source: www.floodinfo.ie – provided by the Office of Public Works).

Contains data from © OpenStreetMap contributors.

Portions of the existing paths and the proposed greenway are below the 10% AEP flood level.

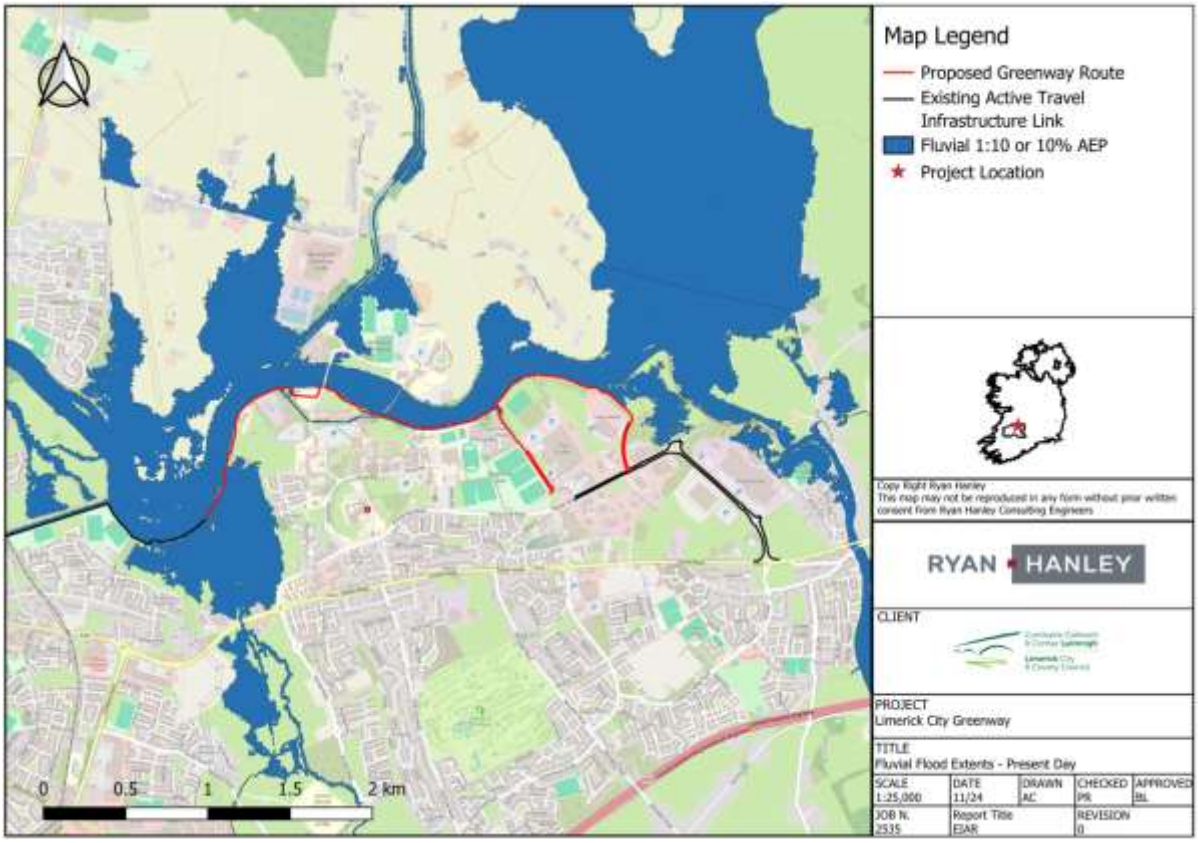


***Figure 8-10** Present Day fluvial flood risk, high probability (i.e. 10% AEP) event flood extents*

Figure 8-11 ***Present Day flood risk, medium probability (i.e. 1% AEP) event flood extents***

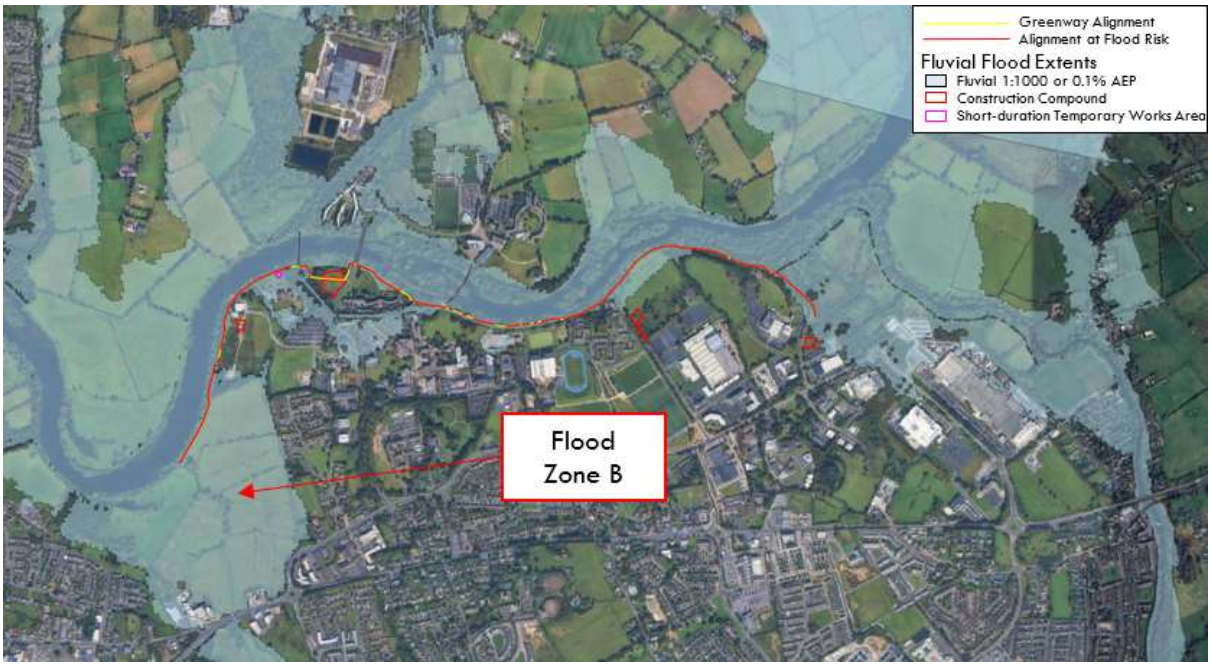


***Figure 8-12** Present Dat flood risk, low probability (i.e. 0.1% AEP) event flood extents*

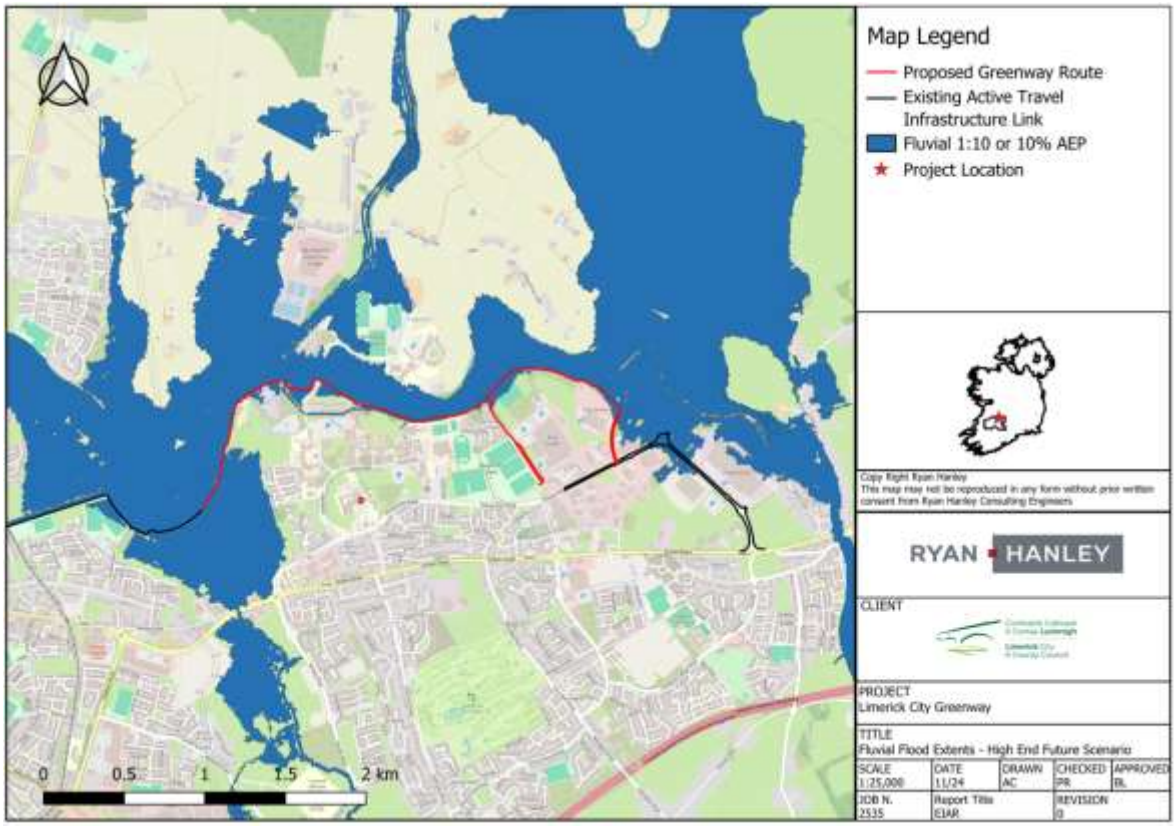


***Figure 8-13** High End Future flood risk, high probability (i.e. 10% AEP) event flood extents*

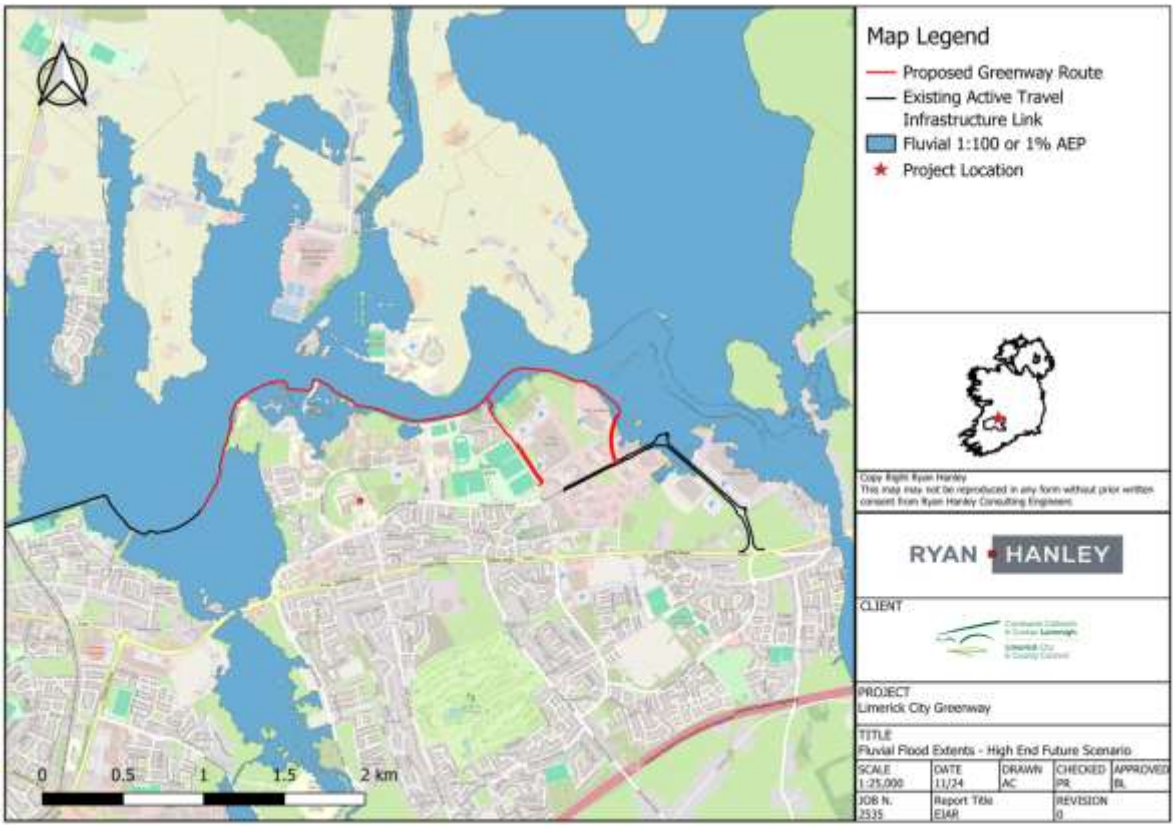


Figure 8-14 High End future flood risk, medium probability (i.e. 1% AEP) event flood extents

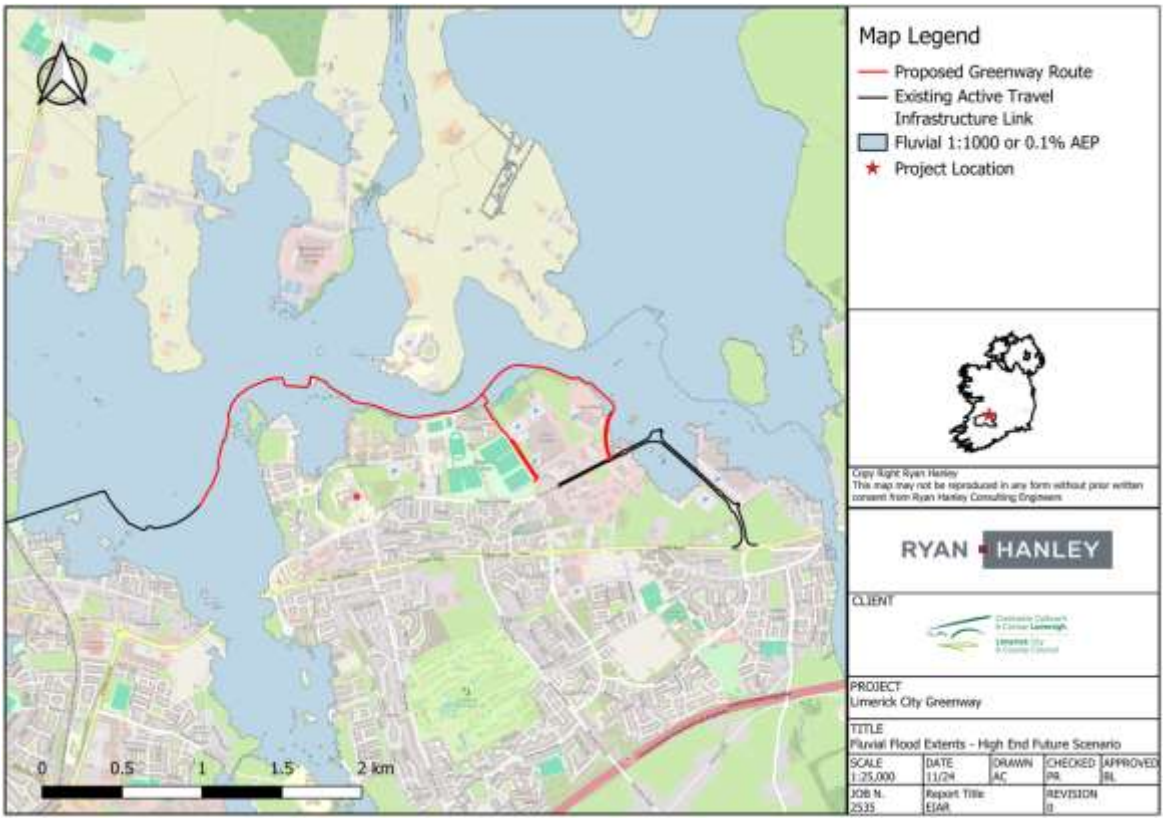


Figure 8-15 High End future flood risk, low probability (i.e. 0.1% AEP) event flood extents

A review of the OPW modelled flood levels at the nodes closest to the three bank reinforcement locations upstream, central and downstream) has been undertaken. These are model nodes SHAN05, SHAN07 and SHAN08. Refer to Figure 8-13.

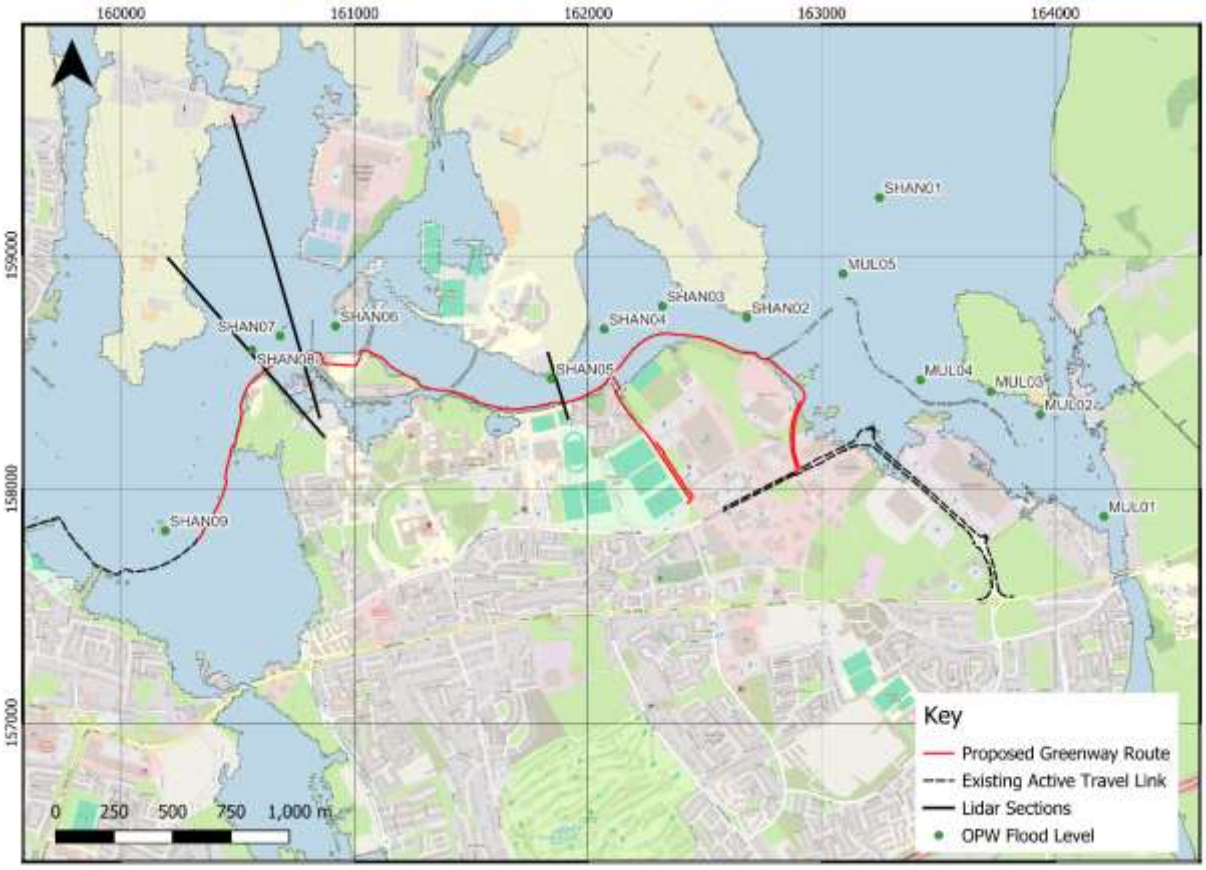


Figure 8-16 OPW modelled flood node locations, overlain with LiDAR sections locations. 1,000 year present day flood extent shown for indication of River Shannon floodplain.

The flood level at each location has been compared with a cross-section of floodplain taken from OPW LiDAR data to estimate a cross-sectional flow area at each water level. The cross-sectional flow area at each location is substantial even during the QMED return period (Table 8.8 and Table 8).

Ground levels adjacent to the DS bank reinforcement location (SHAN08) are generally between 5.2 to 6.0 m AOD, therefore the existing bridge structures at the location are likely to be surcharged or submerged during fluvial flood events occurring on the River Shannon in excess of the QMED return period. Ground levels adjacent to the Central bank reinforcement location (SHAN07) are generally between 5.8 to 6.4 m AOD, therefore the existing structures are likely to be surcharged or submerged during the 1% Annual Exceedance Probability (AEP) and greater fluvial flood event occurring on the River Shannon. Ground levels adjacent to the US bank reinforcement location (SHAN05) are generally between 7.8 and 8.4 m AOD, therefore the existing bridge structure is likely to be surcharged above the 10% AEP return period and submerged during fluvial flood events greater than the 1% AEP event on the River Shannon.

Surface water will be managed through a series of existing open drains alongside the proposed Greenway and existing culverts under existing paths, proposed open drains alongside the proposed Greenway, and new culvert pipes under the proposed path.

There will be 5 No. box culverts constructed in existing drainage channels where the proposed Greenway will cross it. Four are new culverts and one is a replacement culvert. They will have a minimum diameter of 0.9m and range up to 2.0m cross sectional diameter (exact diameters to be confirmed after completion of the Section 50 assessment).

22 No. precast concrete culvert pipes of 0.5m diameter and 6-8m in length and associated headwalls will cross under the proposed Greenway path at 100m intervals where there are no existing culverts. The purpose of these culverts is to enable groundwater which collects in the open drains alongside the path to be discharged to the rivers. The open drains will be shallow, approximately 1.0m wide and 200mm deep. The drains will collect storm water flows from the proposed path and runoff from the hilly green field in the IDA's National Technology Park. Water will flow in the drains to the 22 No. culverts and pass under the proposed path.

Following flood events there is a risk of debris in the minor watercourses culverts and drains pipes. Post flooding maintenance to clear the culverts of debris will be required by LCCC.

Table 8.8: OPW modelled flood levels on the River Shannon (Lower) at the location of the proposed bank reinforcement

Location	Return period (Annual Exceedance Probability) and water level (m AOD)			
	50% AEP (QMED)	10% AEP	1% AEP	0.1% AEP
US bank reinforcement (SHAN05)	6.48	7.01	7.66	8.23
Central bank reinforcement (SHAN07)	5.15	5.77	6.38	6.94
DS bank reinforcement (SHAN08)	5.14	5.75	6.36	6.92

Table 8.9 The estimated cross-sectional flow area of River Shannon for each return period based on OPW modelled water levels and OPW LiDAR digital terrain model

Location	Return period (Annual Exceedance Probability) and flow area (m^2)			
	50% AEP (QMED)	10% AEP	1% AEP	0.1% AEP
US Bank Reinforcement (SHAN05)	119.9	177.1	248.0	310.7
Central bank reinforcement (SHAN07)	303.1	810.9	1379.1	1946.8

DS bank reinforcement (SHAN08)	150.8	498.7	820.1	1131.0

OPW surface water flood mapping is not available for Limerick or the surrounding area. To identify potential surface water flooding pathways to the proposed Greenway a GIS watershed analysis was undertaken utilising the OPW LiDAR data at the proposed Greenway. Refer to Figure 8-17. The analysis has identified seven potential surface water flow routes which may materialise during or shortly after an extreme rainfall event to the south of the proposed Greenway. Four of the surface water flow routes appear to be associated with minor watercourses close to the proposed Greenway and are not considered to be surface water flow routes. These are:

- land drains/minor streams discharging into the River Groody to the west of the proposed Greenway;
- one which flows through the main university campus to the Limerick Wastewater Treatment Works (WwTW) at the western extent of the proposed Greenway;
- Thomond College towards the centre-west of the proposed Greenway; and,
- East of the Cook Ireland Limited Campus, which is east of the proposed Greenway,

One surface water flow route through the playing pitches in the UL Campus may be a source of flood risk to the proposed Greenway during an extreme rainfall event, however considering the local topography, which slopes towards the River Shannon for the extent of the proposed Greenway, it is unlikely that surface water would pond on the proposed Greenway and would in all likelihood discharge to the River Shannon. The other two flow routes are and on the northern banks of the River Shannon and would not impact the proposed Greenway. Flood risk from surface water to the proposed Greenway is therefore considered to be low.

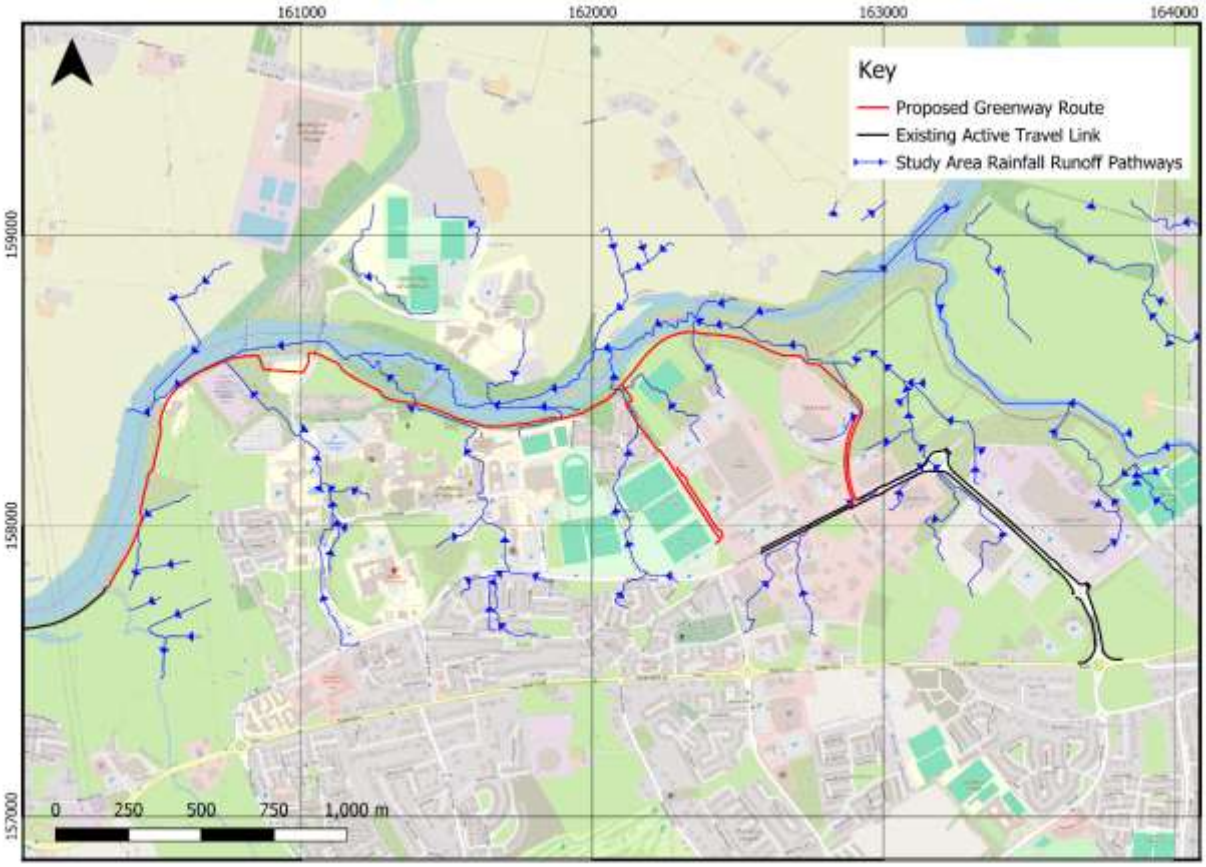


Figure 8-17 OPW LiDAR generated surface water flow routes which may impact the proposed Greenway

The aquifers underlying the proposed Greenway are classified as 'Lm' Locally Important Bedrock Aquifer (Recharge coefficient: 22.5%; and recharge 118 mm/yr). Groundwater vulnerability, a term used to represent the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities, is 'Moderate' (limestone till). Flood risk to the proposed Greenway from groundwater sources is low, considering only moderate productivity from the bedrock aquifer and the general topography surrounding the proposed Greenway which would allow any groundwater emergence to flow overland towards the River Shannon rather than ponding above ground.

8.3.2. Ecological Environment (See also Chapter 6)

8.3.2.1 Biological Status

The receiving waterbody associated with the Study area which could potentially be impacted upon is the Shannon (Lower)_060' (IE_SH_25S012600).

The 'Shannon (Lower)_060' water body WFD status is 'Moderate' (Table 8.10) and the risk status is under "Review" (WFD Status 2016-2021).

WFD classes and Q-Values were obtained from the National River Macroinvertebrate Surveys in Ireland, 2007 – 2018 (Feeley et al, 2020), www.catchments.ie/data and https://gis.epa.ie/EPAMaps/Water.

Table 8.10 Water body classifications and most recent Q value results

Waterbody Name	Station Type	WFD Water body risk	Latest Q Value	WFD Status (of Q value)	Year Sampled
Shannon (Lower)_60	Operational	Review	3-4	Moderate	2020

8.3.3 Chemical Environment

The EPA and Limerick City and County Council have monitored the water quality and chemistry in the Lower Shannon for a number of years. These include monitoring stations on the Lower Shannon at the Bridge within the University of Limerick (ST2) and nearby at Plassey Bridge (ST3). Refer to Table 8.11 and Figure 8-15.

The 'Shannon (Lower)_060' water body WFD status is 'Moderate' according to the 3rd cycle data. The Shannon is not listed as a priority area for action.

Summary statistics were based on reported values provided by the EPA. Where results were reported below the minimum levels of detection, the values provided were used and minimum levels of detection noted. The data show a generally good quality of water in the river, with no specific evidence for any contaminants that may, in association with proposed construction, cause negative impacts.

Table 8.11 EPA/Limerick City and County Council water chemistry monitoring data (www.catchments.ie/data/)

	ST2_Shannon Br UL			ST3_Shannon_Plassy		
Parameter	Dates	Mean ± SD	N	Dates	Value	N
Alkalinity-Total (mg/l $CaCO_3$)						
BOD-5 days Total (mg/l)	2015-2020	1.19 ± 0.61**	74	05/03/2013	1**	1
Conductivity (µS/cm)						
Dissolved Oxygen (mg/l)						
Dissolved Oxygen (% O_2)	2015-2020	98.7 ± 12.7	75	05/03/2013	106	1
pH (pH units)	2015-2020	8.2 ± 0.2	75	05/03/2013	8.4	1
Sulphate (mg/l)						
Temperature (°C)	2015-2020	11.9 ± 4.7	75	05/03/2013	6	1
Ammonia-Total (mg/l N)	2015-2020	0.022 ± 0.009*	75			
Total Oxidised Nitrogen (mg/l N)						
Nitrate (mg/l N)						
Nitrite (µg/l N)						
Ortho-Phosphate (mg/l P)	2015-2020	0.019 ± 0.014	75	05/03/2013	0.018	1

*Minimum Limit of Detection: 0.04; **Minimum Limit of Detection: 2

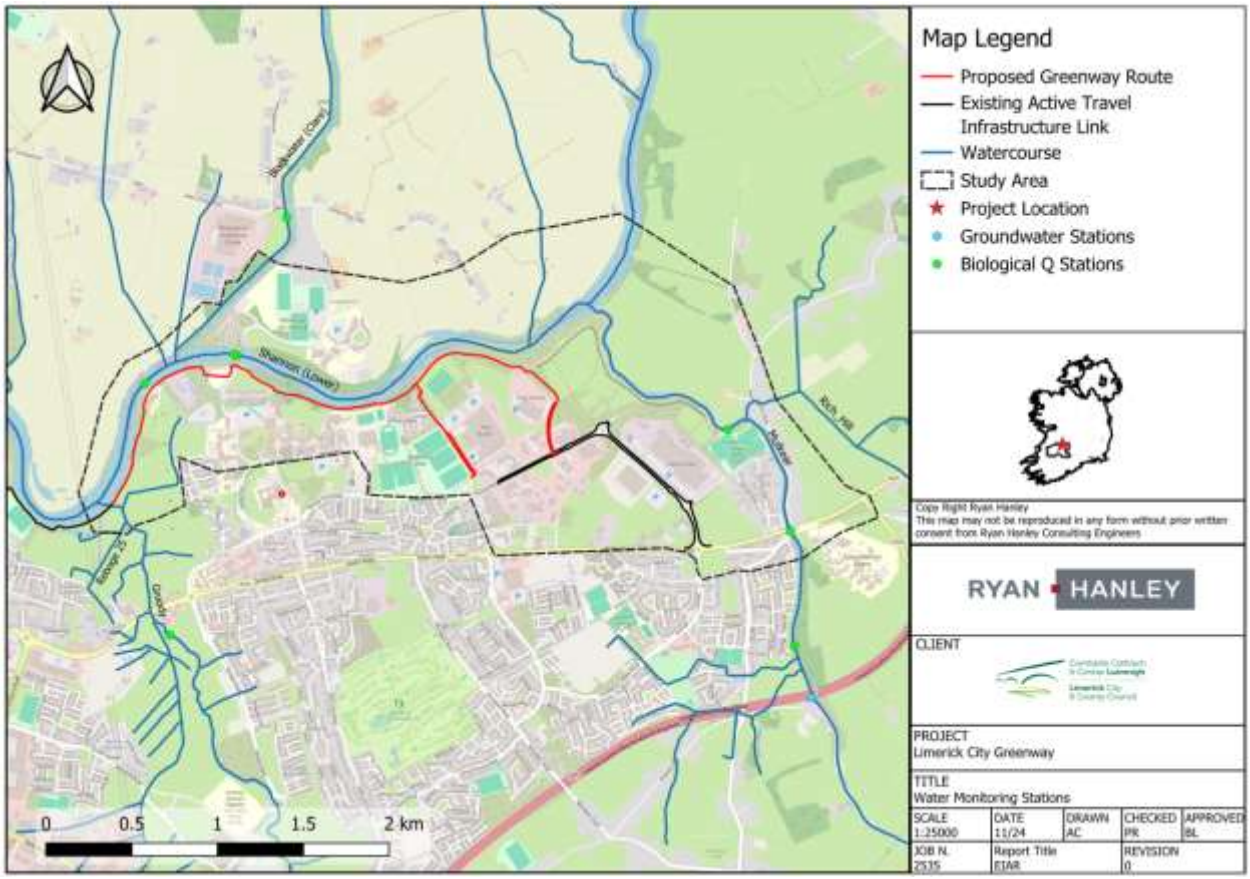


Figure 8-18 EPA River waterbodies and water monitoring stations

The Shannon (Lower)_050 water body is upstream, with a WFD status of 'Poor' and a classification of 'at risk' for the third cycle (EPA, 2018). Limerick Dock (transitional water body) is downstream, also classified as 'at risk'. Groundwater bodies present include Limerick City East and Limerick City North. Limerick City East is classified as "at risk" while Limerick City North is "not at risk".

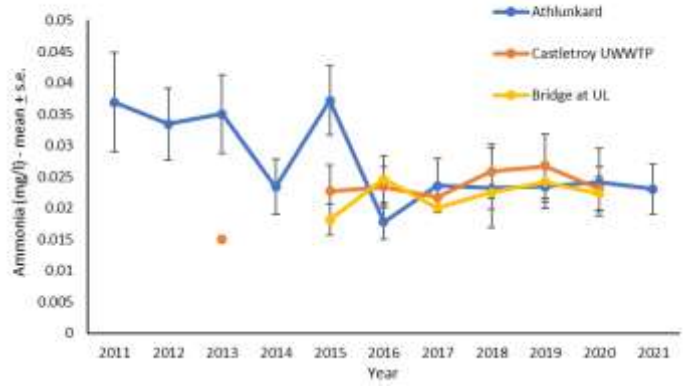
8.3.3.1 Supporting Chemistry Trends

There are three WFD water quality monitoring stations in the vicinity of the Greenway (Table 8.12). Data from the past ten years was examined to identify patterns and/or trends relevant to this assessment.

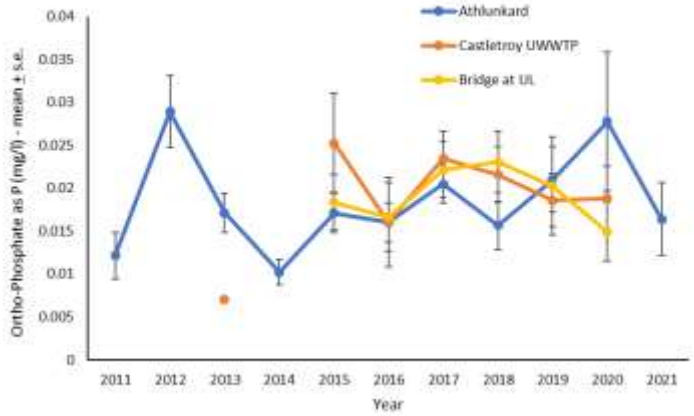
Table 8.12 Details of water quality monitoring data from the River Shannon

Location	Relative to Greenway site	Time Period Included
Shannon River - Bridge at UL	Downstream end of Greenway	2015 - 2021
Shannon River - Castletroy Urban Waste Water Treatment Plant (UWWTP)	Downstream of Greenway	2015 - 2021
Shannon River - Athlunkard	Downstream of Greenway	2011 - 2022

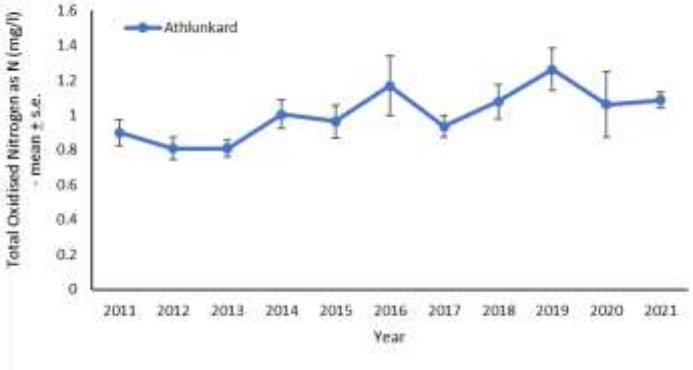
Key water quality parameters for the Lower River Shannon (Shannon (Lower)_60) are shown in Figure 8.16. Total oxidised nitrogen was comprised largely of nitrate, with very low concentrations of nitrite. Ammonia and nutrient concentrations (ortho-phosphate and total oxidised nitrogen) have remained consistently low in the Shannon, and dissolved oxygen saturation high.



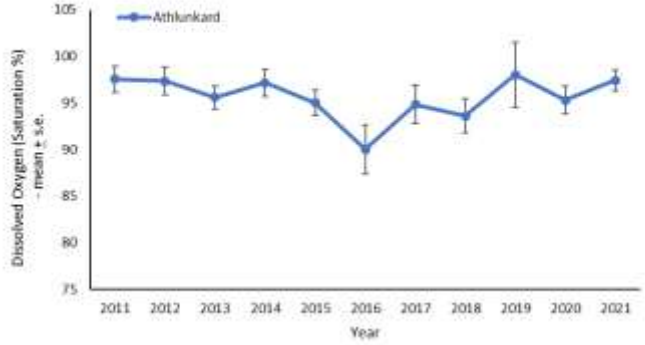
a) Ammonia



b) Ortho-phosphate



c) Total Oxidised Nitrogen



d) Dissolved Oxygen

Figure 8-19 Water quality trends for Shannon L_060

8.3.4 Water Resources and Beneficial Uses

8.3.4.1 Water Supply

The River Shannon at the Study Area are within the River Shannon lower (060) Protected area for River abstraction and Groundwater abstraction (Limerick City East) for drinking water Article 7, Water Framework Directive (2000/60/EC) and European Communities (Drinking Water, No. 2) regulations SI No. 278/2007.

The EPA were consulted for information on public water abstraction within proximity to the Study Area. The EPA advised that the University of Limerick and surrounding area are supplied by the Limerick City Environs Public Drinking Water Supply scheme. The scheme is based at Claireville Water Treatment Plant where two public water abstractions feed the plant, one from the River Shannon via a canal feed into the plant located 4 km upstream from the Study Area. The second public water abstraction is from the Clonlara head race channel which feeds the Ardnacrusha Hydropower plant and confluences with the River Shannon 5km downstream from the Study Area. The scheme supplies a population of approximately 114,138 and is the main source of water for drinking supply in Co. Limerick. A database was also accessed of public water abstractions > 25 m^3 per day for Co. Limerick where one Groundwater abstraction was identified (Figure 8.17). The groundwater well lies within the Study Area and abstracts for cooling purposes.

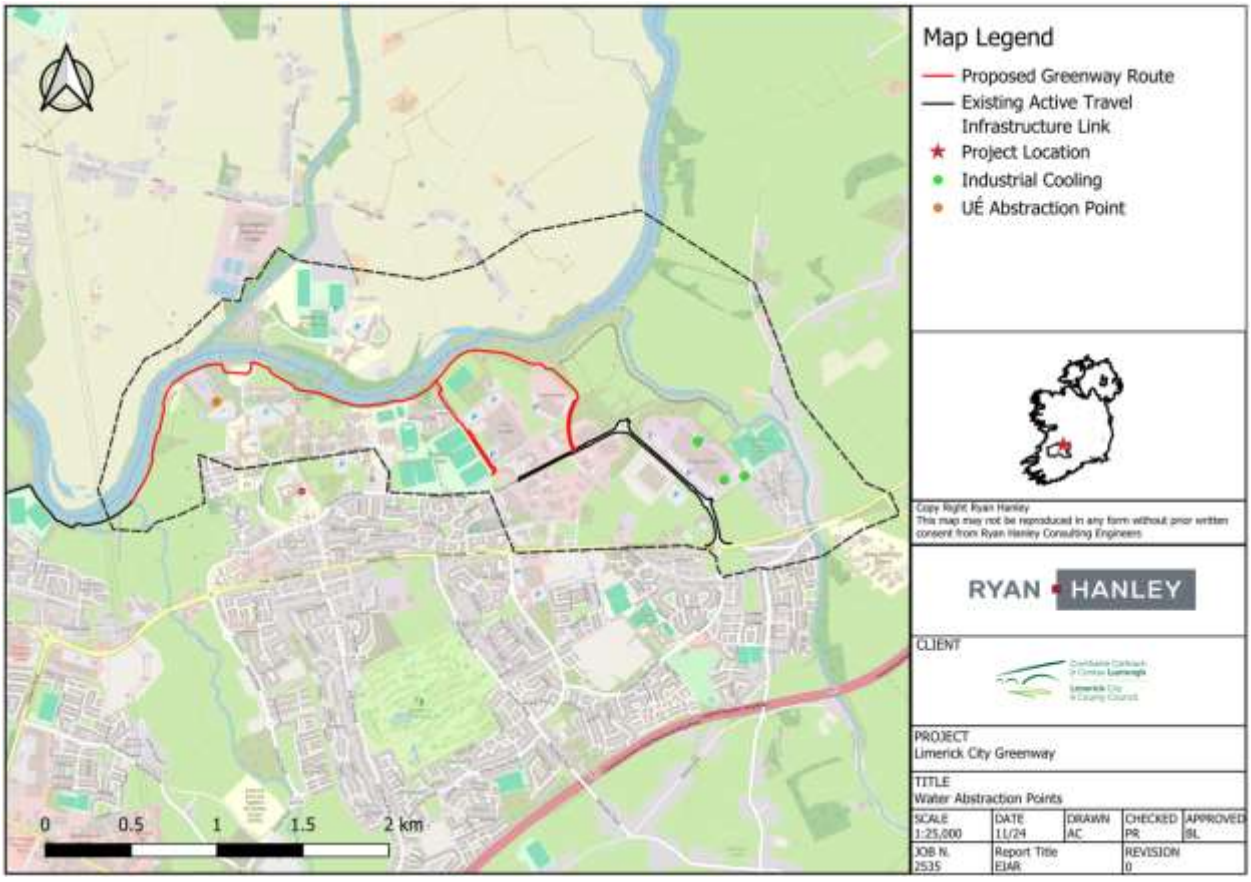


Figure 8-17: Public water abstractions (Source EPA, 2024)

8.3.4.3 Recreation and Landscape Value

The Lower Shannon provides ample opportunities for a range of recreational activities, such as rowing, kayaking and swimming. They are popular with residents, students and tourists in the local area.

The section of the lower River Shannon considered in this report provides valuable salmon and trout spawning and nursery habitats. Catch and release is permitted for salmon in this area, and the stretch is very popular for fly fishing.

Water quality is currently good for both recreational activities and supporting salmonid fish (although note that concentrations of faecal indicator organisms have not been examined). Consideration during construction work should be taken to minimise water quality impacts, both chemically and with respect to mobilisation of fine sediment that may impede any spawning beds.

8.3.4.4 Sub-catchment Pressures

Data concerning significant pressures for the Shannon (Lower)_060 water body were not available. However, the adjoining upstream water body, 'Shannon (Lower)_50' is cited as being under significant pressure for 'hydromorphology' (EPA, 2018).

Further information on pressures obtained from sub-catchment assessments conducted for the implementation of the 3rd Cycle of the WFD through the RBMP 2022-2027(www.catchments.ie/data), from mapping the catchments (https://gis.epa.ie/EPAMaps/Water) and from reviewing the OPW datasets (www.opw.ie) identified the following:

- There are multiple drains that flow either directly into the watercourse or terminate in the riverbank along the surveyed reach. During the walkover, those that were active were discharging grey water, indicative of urban run-off and/ or wastewater, suggesting that there may be point-source pollution and water quality issues throughout this section of the watercourse;
- There is evidence of commonly occurring Invasive Non Native Species (INNS), Himalayan balsam (*Impatiens glandulifera*) and Giant hogweed (*H. mantegazzianum*);
- Castletroy Urban Waste Wastewater Treatment Plant (UWWTP) is adjacent to the proposed Greenway and within the Shannon (Lower)_060 reach; and
- Limerick City East Groundwater body is mapped as under significant pressure from 'agriculture'. A significant agricultural pressure can be diffuse and/or point source of pollution and includes nutrient pollution. No further detail was provided.

8.4 UPDATED SURVEY RESULTS

As part of the update to the original AEA undertaken by APEM, the desk study and field work undertaken in 2021 were repeated by APEM in 2023 to check the continued validity of the original data, and to provide any additional species or site data made available between 2021 and 2023.

Results below were provided by APEM, detailed in their report from November 2023.

8.4.1 Main findings

8.4.1.1 Species

Species data within the vicinity of the site have been refined within the scope of an AEA to include fish, macroinvertebrates, macrophytes, and white-clawed crayfish.

Table 8.73 Fish species recorded in the vicinity of the proposed works

Species	Latin name	Distance	Years
National Biodiversity Data Centre			
European eel	*Anguilla anguilla*	On site	2021 - 2023
Brook lamprey	*Lampetra planeri*	> 2km	2011 - 2021

Species	Latin name	Distance	Years
Sea lamprey	*Petromyzon marinus*	On site	2021 - 2023
IFI Transitional Waters Report 2017 – Shannon and Fergus Estuaries (Coyne *et al*, 2017)			
Ballan wrasse	*Labrus bergylta*	> 2km	2017
Brill	*Scophthalmus rhombus*	> 2km	2017
Brown trout	*Salmo trutta*	> 2km	2017
Common dragonet	*Callionymus lyra*	> 2km	2017
Common goby	*Pomatoschistus microps*	> 2km	2017
Common sole	*Solea solea*	> 2km	2017
Conger eel	*Conger conger*	> 2km	2017
Corkwing wrasse	*Symphodus melops*	> 2km	2017
Dab	*Limanda limanda*	> 2km	2017
Dace	*Leuciscus leuciscus*	> 2km	2017
European eel	*Anguilla anguilla*	> 2km	2017
European seabass	*Dicentrarchus labrax*	> 2km	2017
Fifteen spined stickleback	*Spinachia spinachia*	> 2km	2017
Five bearded rockling	*Ciliata mustela*	> 2km	2017
Flounder	*Platichthys flesus*	> 2km	2017
Grey gurnard	*Eutrigla gurnardus*	> 2km	2017
Lesser sandeel	*Ammodytes tobianus*	> 2km	2017
Lesser spotted dogfish	*Scyliorhinus canicula*	> 2km	2017
Lumpsucker	*Cyclopterus lumpus*	> 2km	2017
Nilsson's pipefish	*Syngnathus rostellatus*	> 2km	2017
Painted goby	*Pomatoschistus pictus*	> 2km	2017
Perch	*Perca fluviatilis*	> 2km	2017
Plaice	*Pleuronectes platessa*	> 2km	2017
Pogge	*Agonus cataphractus*	> 2km	2017
Pollack	*Pollachius pollachius*	> 2km	2017
Poor cod	*Trisopterus minutus*	> 2km	2017
Pouting	*Trisopterus luscus*	> 2km	2017
Roach	*Rutilus rutilus*	> 2km	2017
Sand goby	*Pomatoschistus minutus*	> 2km	2017
Sand smelt	*Atherina presbyter*	> 2km	2017
Scad	*Trachurus trachurus*	> 2km	2017
Short spined sea scorpion	*Myoxocephalus scorpius*	> 2km	2017
Smelt	*Osmerus eperlanus*	> 2km	2017

Species	Latin name	Distance	Years
Sprat	*Sprattus sprattus*	> 2km	2017
Thick lipped grey mullet	*Chelon labrosus*	> 2km	2017
Thornback ray	*Raja clavata*	> 2km	2017
Three spined stickleback	*Gasterosteus aculeatus*	> 2km	2017
Two spotted goby	*Gobiusculus flavescens*	> 2km	2017
Whiting	*Merlangius merlangus*	> 2km	2017
Worm pipefish	*Nerophis lumbriciformis*	> 2km	2017

Table 8.14 Macroinvertebrate species recorded in the vicinity of the proposed works

Waterbody ID	Distance	Years	Order	Family	Genus / Species
National Biodiversity Data Centre					
*	*	2021 - 2023	Unionida	Margaritiferidae	Freshwater pearl mussel (*Margaritifera margaritifera*)
National River Macroinvertebrate Surveys in Ireland, 2007 – 2018 (Feeley *et al*, 2020)					
Shannon (Lower)_050	~ 7 km	2018	Rhynchobdellida	Glossiphoniidae	*Helobdella* sp.
			Acari	-	*Acari* sp.
			Amphipoda	Corophiidae	*Corophium* sp.
				Gammaridae	*Gammarus* sp.
			Diptera	Chironomidae	-
			Ephemeroptera	Caenidae	*Canis* sp.
				Ephemerellidae	*Serratella ignita*
				Heptageniidae	*Heptagenia* sp.
			Trichoptera	Ecnomidae	*Ecnomus tenellus*
				Hydropsychidae	*Hydropsyche* sp.
				Polycentropodidae	*Polycentropus* sp.
			Myida	Dreissenidae	*Dreissena polymorpha*
			Ectobranchia	Valvatidae	*Valvata (Cincinna) piscinalis*
			Littorinimorpha	Bithyniidae	*Bithynia* sp.
			Neotaenioglossa	Hydrobiidae	*Potamopyrgus antipodarum*
			Neritopsina	Neritidae	*Theodoxus* sp.
			Lubriculida	Lumbriculidae	-
			Acari	-	*Acari sp.*

Waterbody ID	Distance	Years	Order	Family	Genus / Species
Shannon (Lower)_060	On site	2018	Amphipoda	Gammaridae	*Gammarus duebeni*
					Gammarus zaddachi
			Coleoptera	Elmidae	*Elmis aenea*
					Limnius volckmari
			Diptera	Chironomidae	-
				Pediciidae	*Dicranota sp.*
			Ephemeroptera	Baetidae	*Alainites muticus*
				Ephemerellidae	*Baetis rhodani/atlanticus*
					Serratella ignita
				Heptageniidae	*Ecdyonurus sp.*
					Heptagenia sp.
			Plecoptera	Leuctridae	*Leuctra sp.*
				Perlidae	*Perla bipunctata*
			Trichoptera	Hydropsychidae	*Hydropsyche sp.*
			Neotaenioglossa	Hydrobiidae	*Potamopyrgus antipodarum*
			Neritopsina	Neritidae	*Theodoxus sp.*

Numerous aquatic macroinvertebrate taxa were identified that are known to be sensitive to reductions in water quality, including Plecoptera (stonefly) and Trichoptera (caddisfly) species. However, no species on this list are considered to be protected or threatened in Ireland (Nelson et al., 2019), with the exception of the freshwater pearl mussel (*Margaritifera margaritifera*).

No historic macrophyte survey data was found for the River Shannon. A review of the NBDC identified records of nine protected plant species between 2021 and 2023, of which three may be found in aquatic environments.

Table 8.15 Protected macrophyte records in the vicinity of the proposed works

Species	Latin name	Distance	Years
National Biodiversity Data Centre			
Irish St John's-wort	*Hypericum canadense*	> 2km	2021 - 2023
Opposite-leaved pondweed	*Groenlandia densa*	> 2km	2021 - 2023
Chickweed willowherb	*Epilobium alsinifolium*	> 2km	2021 - 2023

There were no survey records of white-clawed crayfish were found on the River Shannon. Although no occurrences of non-native crayfish species have been reported in Ireland, multiple occurrences of crayfish

plague have been reported in a number of Irish rivers since 2015, though no records have been reported on the River Shannon (NBDC, 2023b).

8.4.1.2 Field survey

Results from the walkover survey carried out by APEM the 8th of November 2023, highlighted the following:

- Drainage ditches along the route can provide suitable habitat for lamprey ammocoete;
- Slow-flowing aquatic habitats found along the route may provide suitable refugia for salmonids;
- Streams crossing the route may offer suitable habitat for lamprey ammocoete due to their connectivity with the River Shannon;
- The island network splits near the Living Bridge, on the left bank, may offer suitable habitat for salmonids due to the presence of cobble and gravel substrate with boulders. This offers both refugia and foraging habitat for juvenile salmon and trout and potential suitable spawning habitat for adults;
- Lamprey ammocoete habitat was identified both at the upstream end of the Mill Race and further downstream towards the middle of the Mill Race; and
- The River Shannon may offer suitable spawning habitat for both river and sea lamprey.

8.5 IMPACT ASSESSMENT

An analysis of the predicted impacts of the proposed Greenway on the hydrology/ hydrogeology and water quality, during and after the construction phase, has been completed in line with the guidance documents specified in Section 8.2.

The assessments are based on the description of the works and construction methods as set out in Chapter 4 of this EIAR.

8.5.1 Rating Site Attribute Importance

The Site Attribute Importance was determined using NRA (now TII) Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes (2008), and in particular the use of five important criteria from the guidelines – Extremely High, Very High, High, Medium and Low depending on attribute quality (Table 8:3). The two attributes in the Study Area that are potentially affected by the proposed works are lower River Shannon, and the underlying aquifer.

Whilst the Study Area is situated within the Protected Area for Drinking Water River Shannon (lower) and the population supplied is >113,000; the relevant section of the River Shannon is 4km downstream from the abstraction on the River Shannon and not within close proximity to the Clonlara head race abstraction. The influence of the proposed Greenway on drinking water is therefore considered to be negligible. The bedrock aquifer classification of the Study Area is "Locally Important" and "Moderately Productive", there are no group scheme preliminary groundwater source protection areas within the proposed Greenway and as such the scheme has been assigned a rating of; Medium. This is judged on the basis of criteria for rating site attributes - estimation of the importance of hydrology attributes (NRA, 2008).

8.5.2 Do Nothing Scenario

The option assessment considered this solution unfavourable since even if the works are not carried out there would be no negative impacts on the natural surroundings (biodiversity, soils, water, etc.), this would lead to a lack of fulfilment of the proposed objectives in the Limerick Smart Travel Project, slowing down the shift towards more sustainable travel modes.

If the proposed works are not implemented, the environmental, social and economic benefits resulting from the Greenway won't reach the beneficiary local community that would make use of it, increasing unwelcome impacts such as traffic congestion, air pollution, increased greenhouse gases emissions and reduced connectivity between the key hubs within Limerick City.

The "do-nothing" scenario was considered to represent an inappropriate and inefficient use of the Greenway; particularly having regard to the opportunity to provide the much-needed connectivity for the Limerick City area.

8.5.3 Potential Impacts

The potential impacts of the proposed construction activities on the hydrology, hydrogeology, water quantity and quality relate to:

- Construction Phase;
- Use of Potential Water Contaminants; and
- Flood Risk

Potential impacts of the operation of the Scheme are:

- None anticipated

8.4.3.1 Construction Phase: Sediment erosion and ingress into the watercourse generating silt-laden run off & increase in Suspended Solids

Potential Short Term Significant Negative Impact

The Lower River Shannon SAC is designated in part for the presence of EU habitat type habitat type 3260 'Floating River Vegetation', which is known to be present throughout most major rivers in the catchment and was noted during the preliminary walkover conducted in June 2020. This habitat type is particularly important to river habitats, as it promotes flow heterogeneity, fine sediment deposition, and shelter and food for fish and macroinvertebrates.

The River Shannon provides habitat for a number of Qualifying Interests (QIs) within the Lower River Shannon SAC [002165], including brook lamprey, river lamprey, sea lamprey, freshwater pearl mussel and Atlantic salmon. The proposed bank side construction works will take place in accordance with the period prescribed in the Mitigation timing - ecological calendar, so the life stages of migratory fish species will not be impacted by factors such as increased sediment ingress into the watercourse or noise and disturbance associated with installation of sheet piling in the river bank.

The Mitigation timing - ecological calendar will be applied and followed to ensure protection of habitats and species during construction and operational phases of the greenway. In general, the construction works should be planned during the 'green' periods in the calendar year, as long as appropriate mitigation measures are implemented. The exception to this is Fish (salmonoid spawning) because foreshore works (including preparatory work) beside all watercourses supporting salmonids shall be undertaken from May to October (inclusive) and in consultation with Inland Fisheries Ireland (IFI) to avoid accidental damage or siltation of spawning beds.

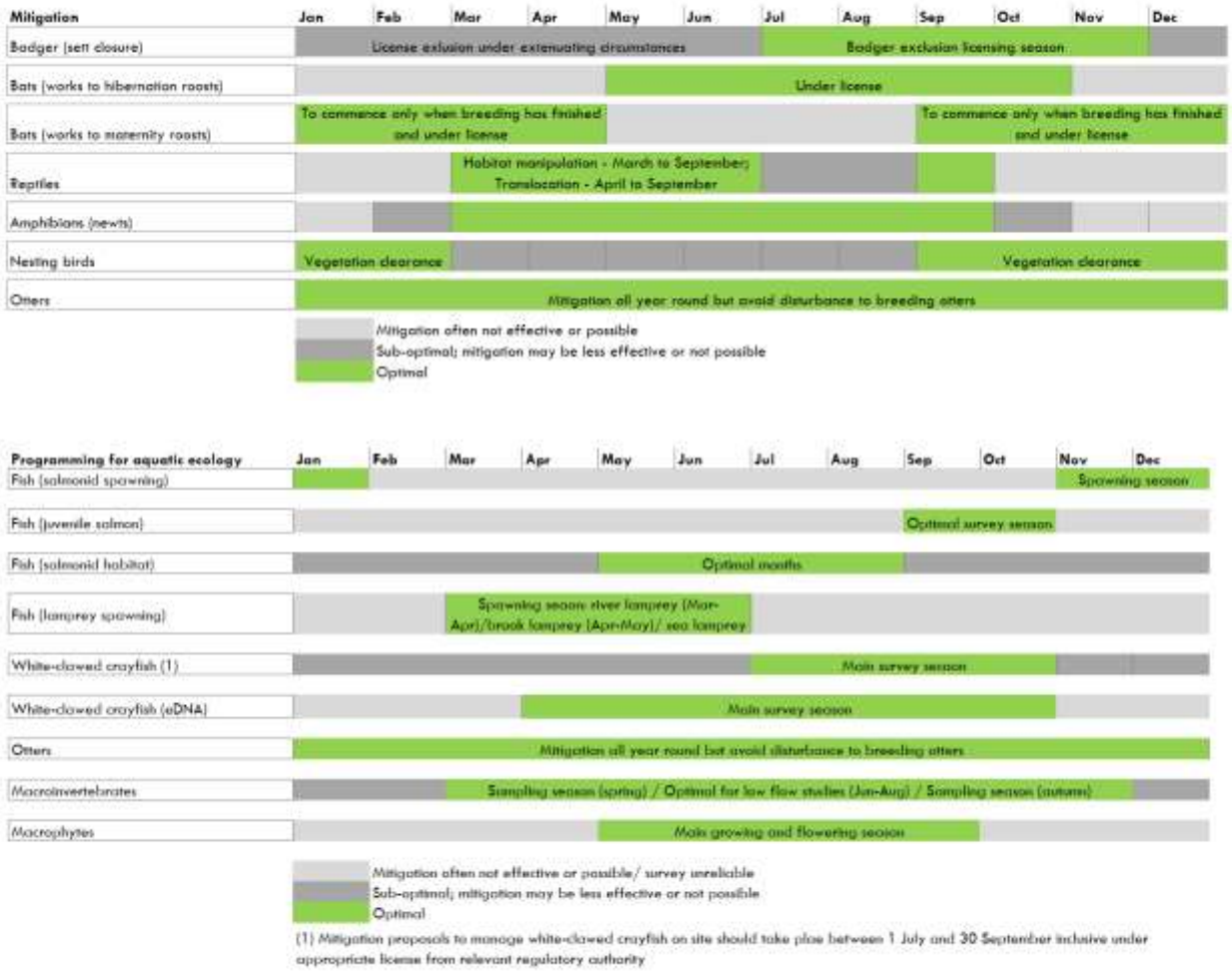


Figure 8 18: Mitigation timing - ecological calendar

Juvenile lamprey habitat was present east of Kilmurray Student Village, in addition to being present at multiple suitable areas along the river, it is therefore possible that these works could negatively impact this habitat.

White-clawed crayfish are known to be present within 2 km of the proposed Greenway. The white-clawed crayfish is protected by national legislation (the Wildlife Act 1976, The Wildlife (Amendment) Act 2000) and is protected under Annex II and Annex V of the EU Habitats Directive (Nelson *et al*, 2018). Direct impacts to these species (such as deterioration in habitat quality due to sediment ingress and/or pollution incidents) are possible. The proposed works are temporary and no long-term impacts on these species are anticipated.

Numerous macroinvertebrate taxa that are sensitive to reductions in habitat or water quality may be present on site, and direct impacts to these species (such as deterioration in habitat quality due to sediment ingress and/or pollution incidents) are possible. This is particularly important on the River Shannon because it was assigned Q-Values of 3-4 (WFD Moderate; slightly polluted) (Feeley *et al*, 2020). Degradation (or further degradation) of the river habitats with increased sediment and/or pollution incidents is possible. However, as previously stated, the proposed works are temporary and no long-term impacts on these species are anticipated.

Mapping of Pollution Impact Potential (PIP) Phosphorus Focused Delivery Flow Paths maps (Figure 8-19) showed areas of converging runoff that result in an increasing accumulation of flow. The red flow paths have the highest surface runoff. Where these cross High PIP areas, higher P losses can be expected. Although the proposed Greenway does not intersect any High PIP areas, the works themselves may be more subject to

increased runoff at these points and particular care should be made to ensure sediment or pollutants are prevented from entering the waterways at these points (particularly east of Construction Compound 4 and west of Construction Compound 2).

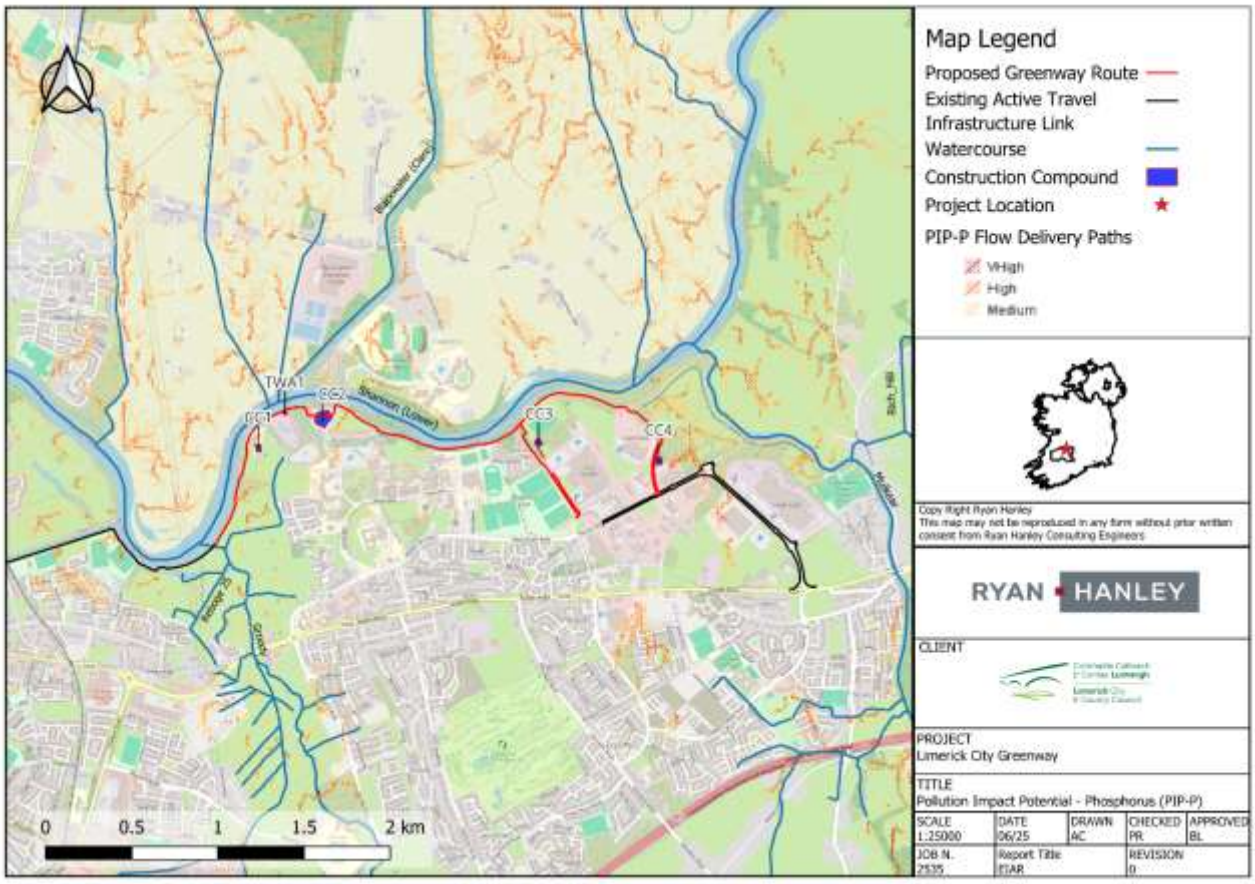


Figure 8-19: Pollution Impact Potential Phosphorus (PIP-P) Flow Delivery Paths in the vicinity of the proposed development

8.4.3.2 Use of Potential Water Contaminants:

Potential Short Term, Significant, Negative Impact

Many substances used and produced on construction sites have the potential to pollute both groundwater and surface water if not properly managed and treated (i.e. lubricants, cement, mortar, silt, soil, waste from site compound facilities, and other substances which arise during construction). The washing of construction vehicles and equipment also poses a pollution risk to watercourses. The spillage or leaking of fuel or oil from fuel tanks or construction vehicles has the potential to contaminate soils, groundwater and surface water.

Such substances entering the receiving surface water and groundwater bodies could damage the habitat of local populations of fish which are qualifying species within the Lower River Shannon SAC (see Appendix), the Floating River Vegetation' habitat for which the Lower River Shannon is designated an SAC, as well as protected species, otter and aquatic invertebrates, and ultimately cause direct harm to all aquatic fauna and reduce water quality.

The are no data available on potential chemical contaminants in riverbed or bankside sediments. If present, these could be mobilised and released into the water during construction. While the area has no major industrial or urban heritage, and is unlikely to be contaminated in this way, it is recommended that a small

number of sediment samples are analysed for key indicators, including metals on the WFD priority substance list.

8.4.3.3 Flood Risk

Potential Short Term Significant Negative Impact

The construction of physical structures, temporary or permanent within proximity to the River Shannon or within adjacent floodplain lands may result in loss of some conveyance or water storage should the river flood.

8.4.3.4 Operational Phase

Permanent Long Term Negative Impact

The introduction of porous but hard-standing area (i.e. the paved tarmacadam surface of the path) is likely to increase surface water runoff locally during or following an extreme rainfall event, this may result in an increase in peak flow within the Rivers Shannon (Lower). Whilst this may represent a potential source of diffuse pollution, the tarmac surface will be porous so there should be minor impact from changing the existing gravel hard standing area to tarmac along the River Shannon north of UL grounds. There will be a new hard standing area 3.5 - 4.0m wide in the IDA grounds but there will be a shallow drain on the non-river side of the proposed path to collect surface water from the hill and discharge it through 21 No. new culverts to the River Shannon. Should the River Shannon experience a significant flood event, and the proposed Greenway become inundated a minor increase in local flood water velocity may be experienced during shallower floods due to decreased surface friction when compared with another surface type e.g. hardcore or grass, but this effect would be quickly diminished should the Greenway become submerged to any significant depth.

A porous material will be used for surfacing and no hard standing areas will be constructed along the vast majority of the proposed path. The exception will be the new concrete bridge west of Plassey Mill, and the disability access ramp at Plassey Beach. These small areas will create a loss of infiltration area.

Physical obstructions during the construction phase (e.g. site equipment, machinery, temporary raised earthworks or construction materials) within the floodplain of the Rivers Shannon (Lower) may impede flood flow routes and remove some floodplain capacity. Materials such as machinery could become mobile during a flood event of significant magnitude which poses a flood hazard and a blockage risk to structures within the River Shannon should the equipment find its way into the watercourse. This risk would be associated with the construction phase and would cease to exist once permanent structures are built.

The construction of three new steel and concrete bridge structures and replacement of two concrete decks with steel decks has the potential to reduce the capacity of existing drainage channels and potentially increase the chance of flooding. However, the width of existing drainage channels and Mill Race channel will remain unchanged, and the bridge structures will be raised well above the water level to the existing path level. The risk of a reduction in the capacity of the existing drainage channels and associated flood risk would be minimal.

Additionally, the ground levels adjacent to the existing structures suggest that these structures are likely to be surcharged and potentially submerged during a significant fluvial flood event on the River Shannon.

No long-term negative impacts on the water quality of the river are foreseen, provided the recommended plans, mitigation measures and monitoring are conducted and an Environment Clerk of Works (ECoW) is employed to oversee the planned works.

8.5.4 Mitigation Measures

8.4.4.1 Construction Phase

Sediment erosion and ingress into the watercourse generating silt-laden run off & increase in Suspended Solids

The following mitigation and monitoring measures will be put in place to protect the ground and surface waters in the Study Area and will ensure no leaching of sediment to enter localised groundwater or surface waters.

Mitigation Measures, Monitoring & Surveys Required

- Works shall be carried out in accordance with the **Mitigation timing - ecological calendar.**
- Measures specified in the Construction Environmental Plan (CEMP) will be adhered to in order to ensure all works are carried out in a manner designed to avoid and minimise any adverse impacts on the receiving environment.
- Measures which are specified in the Invasive Species Management Plan (ISMP) have been produced to reduce the spread of all Invasive Non Native Species (INNS) during the movement of personnel and equipment into and out of the construction area and to ensure Standard 'Check, Clean, Dry' procedures are followed to minimise the risk of INNS spread. A Biosecurity Management section is contained in the in the ISMP and also outlined in the OCEMP.
- Engagement of an Ecological Clerk of Works (ECoW) to supervise the proposed works and implement the recommendation contained within the Water Quality Monitoring Plan and ISMP and surveys of the bankside and close bank channel and all areas where bank side work is proposed.
- Where bank side works are proposed, ingress of sediment into the watercourse must be prevented. Sediment barriers such as sediment netting/fences or silt traps shall be used to temporarily trap sediment to prevent sediment transport into the river, at all interfaces of the works area with a waterbody in advance of construction works on the banks of the river.
- Bankside works should be undertaken at times of good weather and low flow in the River where there is no potential for the works area to become inundated with water and no potential for significant volumes of surface water runoff from the works area.
- Where possible, works should be timed to avoid the key periods of sensitivity for migratory fish species. Works/ construction activities should also be confined to standard daylight hours. To reduce disturbance to fish, areas where bank side works are required should be accessed from the bank/ existing cycle path.
- All works undertaken on the banks should be fully consolidated to prevent scour and run off of silt. Consolidation may include use of protective and biodegradable matting (coirmesh) on the banks and also the sowing of grass seed on bare soil.
- Particular care to prevent run-off of sediment or pollutants into the river should be taken in areas where the potential for the highest surface runoff (east of Construction Compound 4 and west of Construction Compound 2) on the map of Pollution Impact Potential (PIP) Phosphorus Focused Delivery Flow Paths;
- A silt fence should be erected on all sides of the temporary site compounds to prevent any runoff from the perimeter of the compounds.
- Temporary or permanent loss of riparian and marginal habitat during both the pre- and post-construction phases should be avoided.
- To prevent noise and disturbance to designated species and habitats where possible, works should be timed to avoid the key periods of sensitivity for migratory fish species as illustrated in Figure 8.20. Works and construction activities should also be confined to standard daylight hours. In order to reduce disturbance to fish species, areas where bank side works are required should be accessed from the bank/ existing path.

Species	Life stage	J	F	M	A	M	J	J	A	S	O	N	D
Atlantic salmon	Spawning & egg incubation												
	Juveniles												
	Adult U/S migration												
	Smolt D/S migration												
Brook lamprey	Spawning & egg incubation												
	Ammocoetes												
River lamprey	Spawning & egg incubation												
	Ammocoetes												
	U/S migration												
	D/S migration												
Sea lamprey	Spawning & egg incubation												
	Ammocoetes												
	U/S migration												
	D/S migration												

Figure 8-20 Key timings of migratory fish species with the lower River Shannon SAC

- To prevent pollution by leakage or spillage of water contaminants stockpiling should be confined to compounds which are >30m from watercourses.
- There will be no refuelling of machinery near the river channel. Refuelling will take place at designated locations in the site compound (details of site compounds are provided in Chapter 4) on an impermeable surface at distances of greater than 50 metres from the watercourse.
- No vehicles will be left unattended when refuelling and a spill kit including an oil containment boom and absorbent pads will be on site at all times.
- Any fuel that is stored on the site will be in a double skinned, bunded container that will be located within a designated site compound at a location that is removed from the river. The locations of the site compounds are shown on Figure 8-19. All construction materials and plant should be stored in the site compounds. Compounds should be located on ground that is not prone to flooding or should be surrounded by a protective earth bund to prevent inundation. The site compounds will be surfaced with a hard standing to prevent generation of mud. A silt fence will be erected on all sides of the compounds to prevent any runoff from the perimeter of the compounds. The locations of the site compounds will be adequately buffered to prevent any surface water runoff.
- All vehicles should be regularly maintained and checked for fuel and oil leaks
- During the construction phase site materials should, where reasonably practicable be stored outside of the present day high likelihood flood extent. Site managers should regularly consult the Met Eireann flood warnings website https://www.met.ie/warnings/today if significant flooding is expected, construction materials which could become mobile should be anchored securely or moved to a location where flooding is not anticipated.
- The surface area of the proposed Greenway upgrade is approximately 0.03km2, and the path surface will be porous tarmacadam in accordance with TII and NTA design manuals. Considering the underlying bedrock aquifer is only moderate productivity and the catchment area of the River Shannon (Lower) at the Study Area is several orders of magnitude greater than the area of proposed Greenway, it is not considered that mitigation for groundwater recharge is required and surface water should be allowed to flow freely overland towards the River Shannon (Lower) or infiltrate naturally into surrounding ground. This approach should be confirmed with the EPA prior to final design.
- Whilst fast flowing water over the Greenway surface during a flood is a concern, physical interventions will not mitigate this without causing further environmental impacts e.g. diversion of flow paths. Therefore, it is recommended that signage is utilised to identify areas of potential flood risk and advise users not to cycle or walk through water should the river flood, the signage could also recommend users check the Met Eireann flood warnings website https://www.met.ie/warnings/today.

- The review of ground levels around the existing structures has shown they are likely flooded and/or surcharged during significant flood events occurring on the River Shannon, therefore, the new bridge structures in the locations will also experience flooding. The final design of the bridges will ensure that the deck levels match the existing deck levels. The construction of the bridges will be a steel frame design without solid parapets and therefore is unlikely to significantly reduce channel capacity or floodplain capacity. As with other locations of the Greenway where the risk of flooding cannot be mitigated, signage should be utilised to inform users of the potential flood risk and discourage usage should the River Shannon be within a state of flood.
- It is understood that piles will be designed so that there will be no loss of conveyance of water and no creation of structures that impact floodplains, either during the construction phase or as a result of the final build. In this scenario (which will be confirmed by the construction plan), flood risk as a result of loss of conveyance or water storage would be minimised.

Monitoring

- Daily monitoring of excavations and works areas by a suitably qualified person such as the Environmental Manager (EM) or the Environmental Clerk of Works (ECoW) will occur during the construction phase. Run-off from works, stockpile and/or compound areas will be monitored and observed daily by ECoW to ensure that it is not impacting on any local watercourses.
- Monitoring should occur upstream and downstream of any areas of active construction.

8.5.5 Residual Impacts during the Construction Phase

Improvement of flood protection at rear of Fisherman Cottages

Long Term Perceptible Positive Impact

The residents in the Fisherman Cottages requested LCCC to resolve surface water drainage problems that is caused by rising water levels from water associated with the Plassey Mill Race. This project will deliver a solution because the proposed raised bank at the rear of the cottages will create an earth bund and prevent surface water from entering the read of the cottages. Any surface water that accumulates with the earth bund area can be drained through proposed drains towards the Mill Race. A flap valve on the outlet pipe will prevent backflow into the rear of the cottages.

Generation of Silt-Laden Run-off & Increase in Suspended Solids

Short Term Imperceptible Negative Impact

With the abovementioned mitigation measures and monitoring in place, the residual impact on water quality resulting from the generation of silt-laden run-off and increase of suspended solids during the construction phase of the scheme is anticipated to be short term imperceptible negative impact. No significant effects or deterioration in water quality are anticipated.

Use of Potential Water Contaminants

Short Term Imperceptible Negative Impact

With the abovementioned mitigation measures and monitoring in place, the residual impact on water quality resulting from the use of potential water pollutants during the construction phase of the scheme is anticipated to be short term imperceptible negative impact. No significant effects or deterioration in water quality are anticipated.

Invasive Species

Short Term Imperceptible Negative Impact

With the abovementioned mitigation measures and adherence to control measures contained in the Invasive Species Management Plan (ISMP), it is anticipated that no change in the distribution of Invasive Non Native Species should take place during the construction phase of the scheme. A short term imperceptible negative impact is anticipated.

Loss of Riparian and Marginal Habitat

Short Term Imperceptible Negative Impact

With the abovementioned mitigation measures including limited bank side works and no in-stream and proposed mitigation measures, it is anticipated to be short term imperceptible negative impact. No significant effects or loss of riparian and/or marginal habitat is anticipated.

Migratory Fish Species

Short Term Imperceptible Negative Impact

With the abovementioned mitigation measures so that construction works are timed correctly and key periods of sensitivity for migratory fish species are adhered to. No significant effects or spawning, egg incubation, ammocoetes, and migration are anticipated.

8.5.6 Cumulative and In-Combination Impacts Assessment

8.4.6.1 Cumulative Impact Assessment

All elements of the proposed development were assessed in order to identify any cumulative effects.

Although individually a scheme may have an insignificant impact on WFD quality elements within a reach, the combined effect of several schemes within a water body may cause deterioration. The cumulative effects of existing pressures and other planned schemes that may have similar effects within a water body must be considered in combination with the impacts of the proposed scheme.

The risk of flooding is relatively high so works in Flood Zone A area should be planned when river levels in the River Shannon are historically low (i.e. Irish summer). Works shall also be planned in accordance with the ecology calendar.

Site activities during the construction phase have the potential to give rise to water pollution, and consequential impacts on flora and fauna. Extensive mitigation is proposed to minimise the potential for water pollution arising from the works which also minimises the potential for any cumulative or interacting effect.

8.4.6.2 In-Combination Impact Assessment

The proposed Scheme has been considered, in combination with plans and the projects set out in Chapter 3, Section 3.5 of the EIAR in order to assess any in-combination effects.

The Limerick Development Plan 2022-2028 and planning register were consulted to identify any developments which could cause cumulative impacts with the proposed project. No major developments that would have in-combination effects are planned for the area within this time period.

For the reasons outlined in this Chapter and with mitigation measures in place, the proposed work will not lead to any deterioration in water quality status. Following a detailed assessment of the receiving environment and potential impacts of the proposed Scheme in combination with the potential impacts of the

plans and projects set out in Chapter 3, Section 3.5, no potential for significant in-combination cumulative effects on water are anticipated.

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