Chapter 8
Soils and Geology

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Chapter 8 Soils and Geology

8.1 Introduction

This chapter describes the natural characteristics of the receiving environment of Flood Defences West (hereafter the 'proposed development') and its immediate surroundings, in terms of soils and geology. The likely significant impacts of the proposed development on these resources are assessed and where required, mitigating measures are put in place to avoid, reduce or minimise the impact of the proposed development on soils and geology.

This chapter outlines the existing ground conditions, with the predicted impacts assessed on the basis of the relevant construction methodology and particular soil characteristics.

Measures to mitigate the likely significant adverse impacts of the proposed development are detailed, and residual impacts are described. This chapter initially sets out the methodology used (Section 8.2), describes the existing soils and geology environment (Section 8.3), examines the predicted impacts of the proposed development (Section 8.4), proposes mitigation measures (Section 8.5), and identifies residual impacts (Section 8.6).

8.2 Methodology

8.2.1 Methodology, Directives and Guidance documents

This chapter is prepared having regard to the Environmental Impact Assessment (EIA) Directive 2011/92/EU (as amended by Directive 2014/52/EU) and the following guidance documents:

- Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes (TII, 2008);
- Draft Guidelines on the Information to be contained in Environmental Impact Assessment Reports (EPA, 2017);
- Advice Notes for Preparing Environmental Impact Statements (EPA, 2015);
- Advice notes on Current Practice in the Preparation of Environmental Impact Statements (EPA, 2003); and
- Guidelines on the information to be contained in environmental impact statements (EPA,2002).

8.2.2 Available Information and Data Collection

Site Walkover

The extent of the proposed development area was walked by the chapter author (ROD's senior geotechnical engineer) in December 2018, under lookout protection by Iarnród Éireann (IÉ) staff. An inspection of the existing masonry quay walls and drainage outlet was conducted separately by ROD's structural and drainage engineers from a boat on the River Suir in August 2018.

Mapping and Aerial Photography

Geological mapping from the Geological Survey of Ireland (GSI), covering the subsoils and solid geology of the location of the proposed development was reviewed using the online viewer at www.gsi.ie/mapping.

Open source (Google Earth, Bing Maps) and Ordnance Survey Ireland (OSI) aerial photography was interrogated in order to identify large scale ground characteristics and built environment in the area.

Historical maps dating back to 1830s were reviewed using online viewer at www.map.geohive.ie in order to identify the changes to topography, extents, land use and built environment.

Ground Investigations

Historical ground investigation information for the proposed development area was collated and reviewed using the National Borehole Database available on GSI's Geotechnical web viewer. In-river ground investigations previously carried out for the nearby River Suir Sustainable Transport Bridge, approved by An Bord Pleanála and currently at Detailed Design stage, were also consulted, to provide an additional body of data to inform the assessment.

Ground investigations specific to the proposed development were commissioned by ROD and carried out by IGSL Ltd. in Q2 and Q3 of 2019. The ground investigations were undertaken across the entire proposed development area, with density of investigation points suitable for planning phase and detailed design (IGSL, 2019). The ground investigation briefly comprised of:

- 15 no. cable percussion boreholes;
- 2 no. rotary core boreholes;
- 4 no. trial pits;
- 10 no. dynamic probes, two of which included window sampling;
- 5 no. groundwater monitoring standpipes, one of which included a datalogger; and
- A suite of laboratory testing; including environmental/contamination tests.

A Ground Interpretative Report (IGSL, 2020) and Waste Characterisation Report (O'Callaghan Moran, 2020) were prepared on the basis of the data acquired from this ground investigation campaign, which have fed into the soils and geology assessment of the proposed development.

8.3 Description of Receiving Environment

8.3.1 General Description

The proposed development comprises c.1.1km of flood protection measures. The location of the proposed development is along the north bank and within the foreshore of the River Suir in Waterford City, Co. Waterford. The R680 Rice Bridge and the Waterford railway station, Plunkett Station are located at the easternmost extent of the site while the Iarnród Éireann (IÉ) rail corridor and the Sallypark industrial park bound the site to the north. The River Suir and the existing quay wall run immediately to the south of the site.

The western end of the study area, including the proposed temporary compound location, is at the industrial estate and level crossing approximately 1500m northwest of Plunkett Station.

The photograph depicting the typical receiving environment is shown in Plate 8.1. Flat topography with rail corridor running roughly parallel to the existing quay wall is visible,

as is the surficial deposit of Made Ground (rail ballast) on landside and cohesive alluvium in mudflats. The photograph was taken by G-NET 3D in March 2021 from Terminus Street overbridge (at approx. Ch.360, see Figures 4.1 to 4.6 in Volume 3 for chainage reference points) looking westwards.

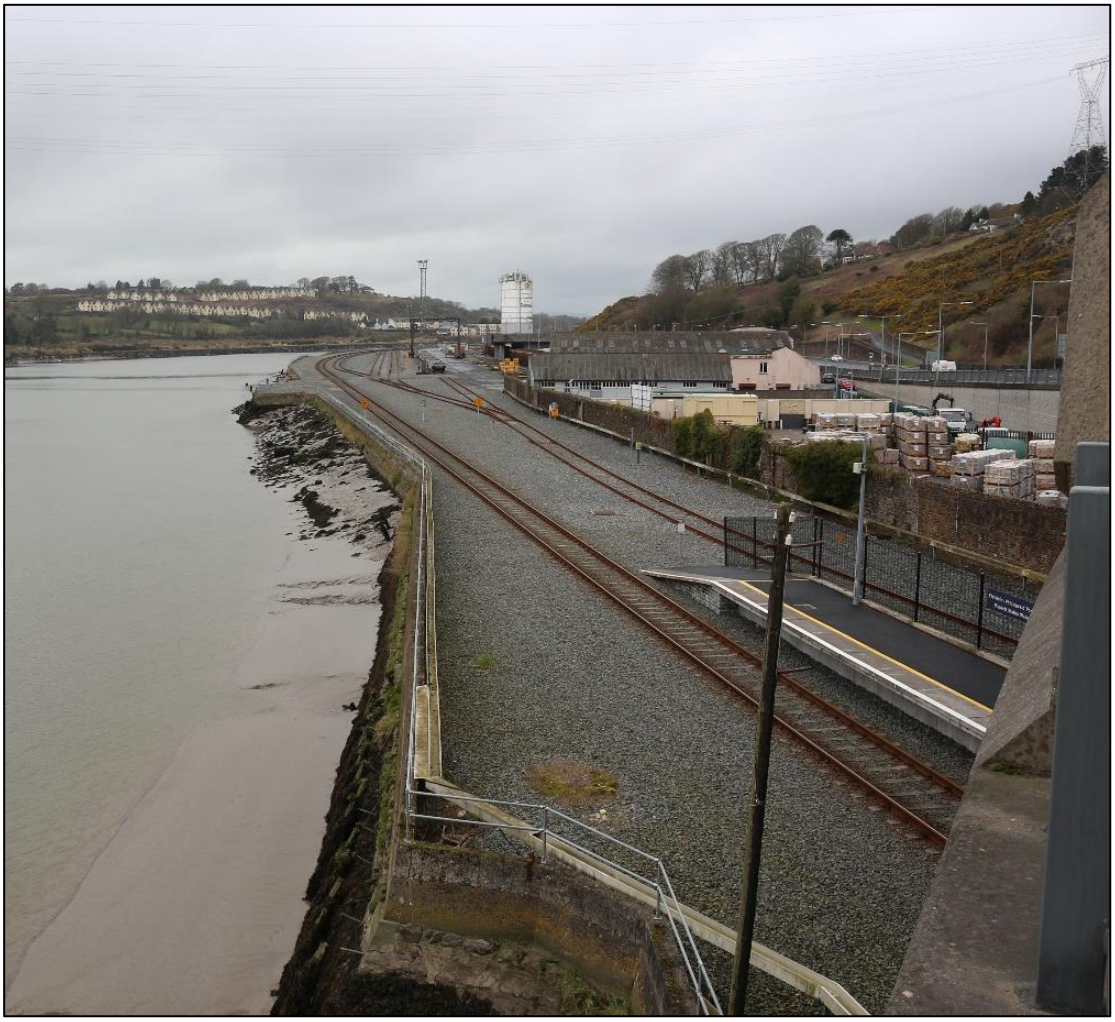

Plate 8.1 **View of a receiving environment. Photo taken by G-NET 3D in March, 2021**

The historical maps show that up to 1850s, the land use of the area was a mix of disused and agricultural land. The site of the current Plunkett Station was residential. The shoreline at the time was similar to the current quay wall alignment, although in some areas the northern bank of the river was set back up to 10m from its current position. With the introduction of rail infrastructure in the second half of 19th century, the land use within the site of proposed development was changed into railway. The current quay wall alignment was set by fortifying the existing shoreline and extending up to 10m into the river in some areas by filling the area with Made Ground. During 20th century, the landing stages built in the mudflats were gradually demolished. The latest major changes to the site were made in the 1990s at the eastern end of the proposed development, when the road infrastructure in front of Plunkett Station was upgraded, including the construction of Terminus Street bridge and Rice Bridge roundabout.

No Geological Heritage sites are present within or in vicinity of the study area.

8.3.2 Topography

The area is flat, with elevations typically ranging between +2.1 mOD in vicinity of the Plunkett station and +3.9 mOD at the western end of the proposed development. The terrain generally falls very gently from west to east but contains some local undulations. The highest point of mudflats in front of the existing quay wall ranges between -1.00 mOD and +0.5 mOD. To the north of the railway lines and the R448, outside the site extents, the topography rises very steeply along the Mount Misery hill.

8.3.3 Bedrock Geology

The bedrock geology was inferred from the GSI's Bedrock Geology maps and confirmed by visually observing the outcrops in the vicinity of the proposed development by means of a site visit.

From the eastern end, approximately two thirds of the proposed development area is underlain by laminated green to grey slates and shales, interbedded with green or pale-grey siltstones and occasional andesitic flows and tuffs of the Ballylane Formation from the Ordovician period. A significant outcrop of this formation is visible immediately to the north of Plunkett Station, on the southern slope of Mount Misery hill. This slope has a history of slope instability (landslides and rockfalls). A Part VIII planning application was approved by WCCC in January 2019 to carry out remedial works to the slope, in order to reduce the risk of future landslides. The likelihood of significant impacts to the proposed development is as low as reasonably practicable (ALARP), as described in Chapter 18 Major Accidents and Disasters of this EIAR.

The bedrock was encountered at very shallow depths of between 1 and 3 m below ground level during ground investigation in front of (to the south of) Plunkett Station, in the area where an impermeable trench is proposed. West of R448 Terminus Street bridge the depth to bedrock is significantly deeper (typically larger than 10m), as the area is at a further distance from Mount Misery hill.

From the western end, the extents of the remaining area of the proposed development (from approximately Ch.920 westwards) are underlain by the red and brown conglomerates and sandstones of Carrigmaclea Formation from Upper Devonian period, sitting unconformably over the Ballylane formation (see Figure 8.1 in Volume 3 of this EIAR). The Carrigmaclea Formation outcrop is visible north of R448 where rock benching works are visible. The depth to bedrock in the western third of the area is larger than 10m below ground level.

8.3.4 Quaternary Sediments

At the eastern end of the proposed development, to the south of the Plunkett Station and below its ancillary car parks, the quaternary sediments typically consist of dense granular Made Ground (gravels and cobbles) on top of shallow siltstone/shale bedrock.

From the Terminus Street bridge to the western end of the proposed development, the ground model is relatively homogenous, consisting of three major layers as described in Table 8.1 below. The table refers to the ground profile along the cess, between the existing masonry wall and the nearest rail tracks.

Table 8.1 Quaternary sediments summary profile from Ch.370 to Ch.1090

Soil Layer	Thickness	Description
Made Ground	1.0 – 6.2 m	Heterogenous non-engineered fill placed to extend the shoreline, level the topography and provide backfill to quay wall and foundation to rail tracks. Typically described as silty sandy GRAVEL with cobbles. Permeable, groundwater described as tidal-responsive. Thickness typically decreasing east to west.
Alluvium	5 - 15 m	Soft to very soft sandy slightly gravelly SILT, occasionally organic in upper layers. Isolated pockets of PEAT present locally. Occasional granular alluvium lenses – described as loose silty sandy GRAVEL.
Glacial overburden	1 – 5 m	Typically medium dense to dense SAND and GRAVEL overlying weathered bedrock.
Bedrock	n/a	Ballylane Formation and Carrigmaclea Formation - see description in section above.

Figure 8.1 shows a geological long section taken from the Geotechnical Interpretative Report (IGSL, 2020) which supports and illustrates the typical sediment profile outlined in Table 8.1 above. For reference, the area in the long section relates to approximate chainages Ch.1450 on the left moving towards Ch.380 on the right (see Figures 4.2 – 4.6 in Volume 3 for chainage references).

The thickness of the layers in Table 8.1 above decrease and the rockhead level increases, as you travel north throughout the site, perpendicularly to the quay wall.

To the south of (in front of) the quay wall in the mudflats and the riverbed, the ground layer descriptions are similar to those outlined in Table 8.1, except that no Made Ground is present. The thickness of alluvium varies within the mudflats and the riverbed, while the rockhead level continues to fall as you approach the centreline of the river.

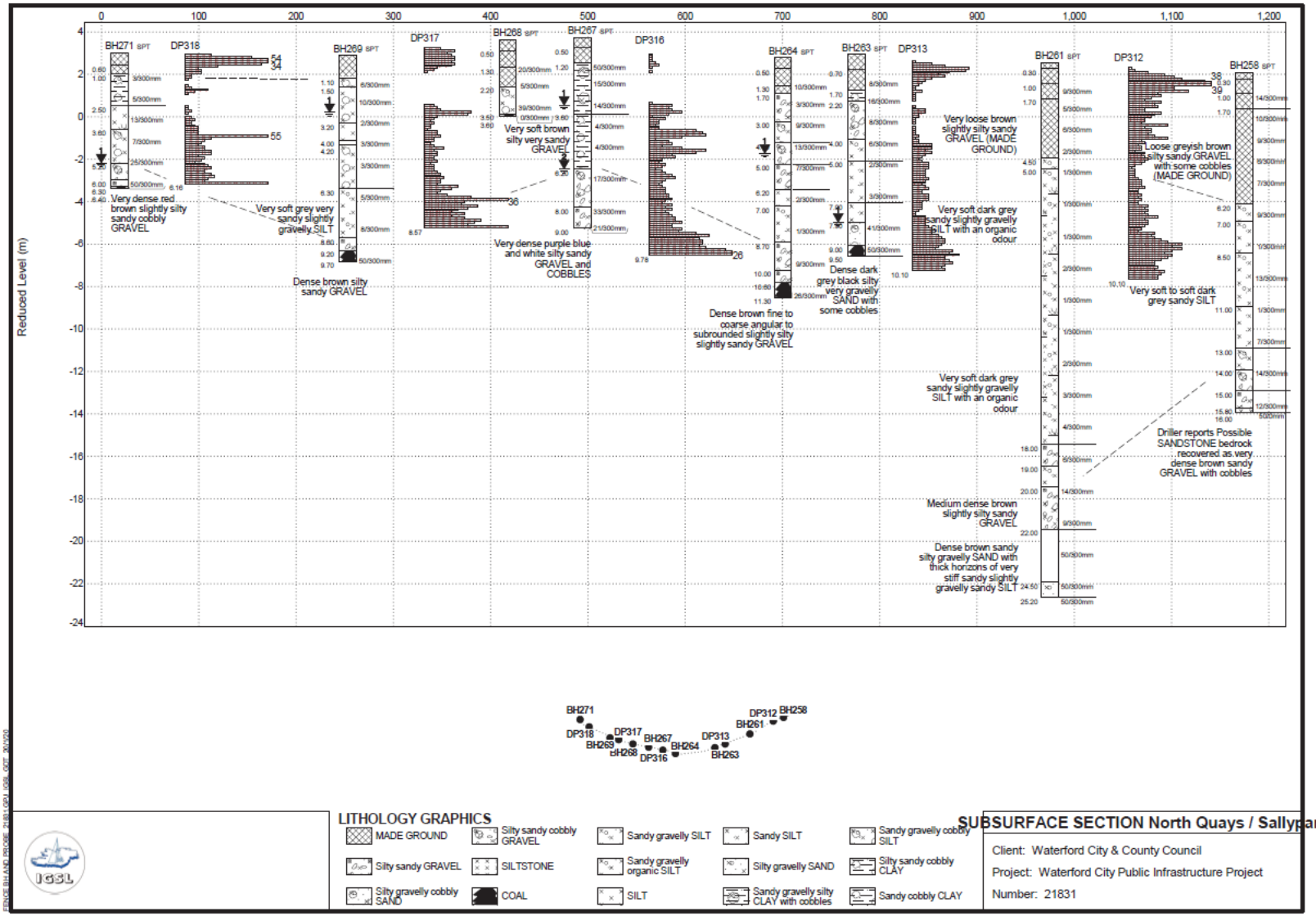

Figure 8.1 Geological long section at Sallypark Industrial Site (taken from IGSL, 2020)

8.3.5 Contaminated Soil

Waste Classification and Waste Acceptance Criteria (WAC) analysis were carried out on 36 samples from across the proposed development area. WAC is undertaken on samples for the purpose of determining which landfill can receive the generated waste. The samples are tested for an array of geochemical determinants and the results compared to established limits, typically classifying samples as inert, exceeding inert and hazardous.

All samples were classified as non-hazardous. Traces of asbestos were detected in a single sample, but the sample is classified as non-hazardous as the level detected was <0.001%. This sample was taken at one of the historical landing stages at Ch.570, see Figures 4.1 to 4.5 in Volume 3 for chainage references.

Half of the samples (18 out of 36) meet the inert WAC. Such material is suitable for recovery at a licensed/permitted soils recovery facility, or disposal to an inert waste licensed landfill. Twelve samples meet the inert WAC with increased limits. Such material is suitable for disposal at an inert landfill with increased limits. Five samples exceed the threshold of inert WAC with increased limits. Such material is suitable for disposal to a non-hazardous waste landfill. A single sample containing asbestos also exceeded inert WAC with increased limits, and as such, the material must be sent for disposal outside of Ireland to a facility licenced to accept such material. These materials will all be subject to review and approval of the facility operator.

The determinants that exceeded inert WAC were chloride, sulphate, total dissolved solids (TDS), antimony, mercury, fluoride and Total Organic Carbon (TOC).

No environmental samples were taken in front of the Plunkett Station and the adjacent car parks, where shallow bedrock was encountered. Due to the traffic usage of the area, there is a potential for elevated levels of contaminants in the ground, particularly hydrocarbons. Contamination testing during works in that area are planned and are described in subsequent sections.

8.4 Description of Potential Impacts

8.4.1 Construction Phase

8.4.1.1 Structural elements

A large extent of the flood defence measures proposed comprise driven steel sheet piles. These linear driven elements, with very slim thickness (up to 20mm) will not require pre-boring, excavation or preparation of in situ ground, and as such, the impact from sheet piling to soils and geology will be neutral. The selected installation method (vibration rather than impact driving) and the designed offset from the existing quay wall will ensure there is no impact to stability of soils.

8.4.1.2 Imported Fill

Where sheet piles will be driven on the river side of the existing quay wall, a gap between the quay wall and sheet piles, typically 1m wide from the face of the quay wall to the back of the sheet pile wall, will be infilled with imported clean granular fill to the existing ground level. Approximately 2,000m^3 of fill will be placed over a length of 540m of sheet pile wall. It is noted that a quantity of non-engineered fill already exists in this 1m wide strip of mudflats, emanating from collapsing quay wall blocks and similar. Additionally, approximately 2,500m^3 of imported selected granular fill will be imported for drainage trench material, for the drainage system being built between the

existing quay wall and the rail tracks. The importation of fill will result in a likely *negative, non-significant* and *permanent* impact.

Up to 350 m^3 of concrete will need to be imported and placed for filling the impermeable trench. Approximately 50 m^3 of in-situ concrete will be required for raising of existing quay wall. A further approx. 70m^3 fill of concrete surround for pump chambers of the pumping stations will be required.

8.4.1.3 Excavations and Disposal of Material

Approximately 2,600m^3 of shallow made ground will be excavated for the purpose of installing the drainage system and pumping stations. To minimise the disposal impacts, approximately half of the excavated made ground will be reused elsewhere on site, typically to level the cess areas behind landside sheet pile wall and the existing quay wall where the ground is falling steeply, or local depressions exist. The receiving ground is of the same composition to the one being deposited. The other half of the excavated material (approx. 1,300m^3) will be disposed of in a suitable licensed facility, in accordance with current regulations.

Approximately 650 m^3 of construction and demolition waste will be generated during the demolition of the handrails and the upper portion of the existing quay wall, with the additional 70 m^3 generated during the removal of a 25m section of the wall to facilitate the construction of pumping station. All of this waste will be considered waste for disposal off-site. The waste will be disposed of in licensed landfills that will receive inert WAC and material exceeding inert WAC.

This will result in *negative, imperceptible* and *permanent* impact.

8.4.1.4 Impermeable trench

A maximum volume of 350m^3 material will be excavated during the construction of the impermeable trenches. The excavated material will be tested to determine the contaminant level and disposed of in a suitably licensed facility according to current regulations. The trench will be infilled with the same quantity of lean mix concrete or similar grout. This new material will have lower permeability than the original excavated material. At specific locations, where trenching would prove to be technically challenging, particularly at the area below the Terminus Street viaduct, the trench will be replaced with low pressure (permeation) grouting behind the existing wall. The grout will be carefully designed and placed to avoid seepage into the River Suir. The characteristics of the ground will change, as the strength will be increased and permeability decreased. The overall trenching operation will result in *negative, imperceptible* and *permanent* impact to soils and geology.

8.4.1.5 Organic matter, erosion, compaction and sealing

Very small quantities of organic matter were encountered in the proposed development area, mainly in small traces in organic silt layer and in the isolated minor peat lenses. These ground layers are typically found at depth of more than 3 m below ground level. They will not be subject to excavation and thus will not be impacted by the proposed development.

Current pathway for erosion includes the waterborne erosion of fine and coarse particles from behind the existing quay wall towards the River Suir. This will be prevented in operational phase by the new sheet pile wall. The impact of the proposed development on erosion is *positive, slight and permanent*. More details are included in section 8.4.2 Operation Phase. The proposed development will have no significant impact to current levels of mudflat erosion, scour and deposition as detailed in the Hydraulic Modelling Report (see, Appendix 10.2 of this EIAR).

The proposed development does not include embankments, or load bearing structures, that would induce the compaction of in-situ material. Furthermore, there will be no compaction of ground from construction machinery as the site boundary primarily contains existing road network and the railway corridor with minimal exposed ground.

It is proposed to infill the area between the existing quay wall and the new riverside sheet pile wall comprising a narrow stretch of ground (up to 1m) over approx. 540m. As the infill material is granular in nature, it will allow continued percolation of surface water into the ground.

Overall, there will be no significant impact related to compaction and sealing from the proposed development.

8.4.1.6 Spillages of Fuel, Oil, Solvents and Paints

Unmitigated, there is a potential risk of localised contamination from construction materials leeching into the underlying soils by exposure, dewatering or construction related spillages resulting in a permanent negative impact on the soils. In the case of soils, the impact is *negative* and *slight* as the requirement of good construction practices will necessitate the immediate excavation/remediation of any such spillage resulting in a very low risk of pollution to the soils and consequently the underlying aquifers.

There is a potential risk of localised contamination of groundwater bodies due to construction activities i.e., construction spillages, leaks from construction plant and material etc. resulting in a *temporary, negative* impact on these water bodies.

8.4.2 Operation Phase

The proposed sheet pile walls will also function as a retaining wall by creating a cut-off for unwanted materials entering the River Suir. These materials include sediment-laden flood and tidal waters receding into the River Suir over or through the existing quay wall which is in poor condition, as well as potential contaminants from the railway yards. The backfilled sheet pile wall will also prevent further fouling of the mudflats and riverbed from the collapsed blocks and parts of the existing quay wall. This will constitute a *positive, slight* and *permanent* impact.

8.5 Mitigation & Monitoring Measures

8.5.1 Mitigation by Design

The construction works will be carried out with the least feasible disturbance of soils. The main flood defence elements, sheet pile wall and remedial works to the existing quay wall, directly avoid any requirement for excavation of in-situ ground and creation of waste.

The quantity of imported backfill for the gap between the sheet piles and the existing quay wall (where sheet piles are installed on the riverside), is minimised by design, as the alignment of the sheet pile wall was carefully selected as close as possible to the existing wall without compromising wall stability. Sheet piles were designed to be constructed on the landside of the existing wall wherever the width of cess allowed for safe day-time works without impact to rail operations, thus further minimising the backfill quantity.

The amount of waste from the excavations required for constructing the drainage system is minimised by reusing approximately a half of this material as a non-structural fill to even out the ground level across the site, wherever possible.

The potential impacts (ground displacement/settlement) on the Dublin to Waterford railway line have been mitigated by design, whereby the works are designed at a sufficient distance from the line, and are such that no temporary or permanent excavation in immediate proximity to the rail line is required, with the exception of shallow trenching for the construction of the drainage system. The potential impacts to the mudflats and riverbed from further deterioration of the existing masonry quay wall are also mitigated by design through the construction of the sheet pile wall and backfill in front of the quay wall at the most critical locations.

8.5.2 Specific Mitigation Measures

The construction works will be carried out with the least feasible disturbance of the soils, minimising the amount of excavated soil with the inert excavated soil will be re-used on site insofar as possible.

Approximately 1,650m^3 of excavated ground material will be exported from the site. In addition to this, approximately 720 m^3 of construction and demolition waste will be generated during the demolition of the handrails and the upper parts of the existing quay wall which will be exported from site. The quantity is very small given the scale of the project, and will be disposed of by the Contractor who will ensure that all subsurface materials excavated during the construction phase of the proposed development are managed in accordance with the relevant waste management legislation. The successful Contractor will ensure that all subsurface materials are removed from the site and sent to authorised waste management facilities (i.e. which hold all relevant, valid permits / licences) which accept the corresponding types of waste. The contractor will be required to submit a Construction and Demolition Waste Management Plan (CDWMP) to the local authority for approval, which should address all types of material to be disposed of. The contractor will undertake the environmental testing of the material to be disposed of in order to determine the waste acceptability characteristics.

All imported material will be sourced from the nearest possible locations. A number of suitable active quarries with all necessary statutory consents exist across County Waterford and southwest County Wexford, such as Oaklands Quarry in Ballykelly, New Ross, Co. Wexford and Cappagh Quarry in Cappagh, Dungarvan, Co. Waterford. Both quarries are accessible from the N25 which links to the site of proposed development via the R448 Terminus Street.

A project-specific Construction Environmental Operating Plan (CEMP) will be prepared for the development by the Contractor for approval by WCCC. It will be maintained by the Contractor for the duration of the construction phase. The CEMP will cover all potentially polluting activities and include an emergency response procedure. All personnel working on the site will be trained in the implementation of the procedures. As a minimum, the CEMP for the proposed development will be formulated in consideration of the standard best practice. The CEMP will include a range of site-specific measures which include:

- Safety measures for working from barges in-river, including but not limited to risk of pollutants from the machinery stationed on the barge and operating with bulk materials such as backfill gravel on the barge;
- Runoff will be controlled and treated to minimise impacts to groundwater and River Suir.

- Temporary storage of any contaminated material on-site shall be carefully managed so as to limit any risk of contaminated surface water runoff leaving the site or infiltrating to groundwater. Runoff from the material shall be directed to a lined pond or temporary sewer/tank and the water shall be disposed of off-site for treatment at an appropriate licenced facility in accordance with the relevant waste management legislation. Alternatively, the material shall be covered while stored to remove the risk of surface water contamination.
- All hazardous materials will be stored within secondary containment, designed to retain at least 110% of the storage contents. Temporary bunds for oil/diesel storage tanks will be used on the site during the construction phase.
- The successful Contractor will ensure that spill kits and hydrocarbon absorbent packs are stored in the site compound, and that operators will be fully trained in the use of this equipment.
- The successful Contractor will ensure that silt and sediment barriers are installed (and maintained in proper working order) at the perimeter of earthworks areas to limit transport of erodible soils to watercourses.
- Where soils are being excavated and removed from site, the successful Contractor will ensure that dust generation will be avoided, by damping down material during excavation and loading onto trucks for off-site removal, if necessary.
- Safe materials handling of all potentially hazardous materials will be emphasised to all construction personnel employed during construction, including the usage of appropriate PPE.
- The successful Contractor will prepare an Incident Response Plan (IRP) which outlines measures to be implemented to prevent and address spillages of hazardous substances.

8.6 Residual Impacts

Residual impacts to soil and geology include the permanent addition of backfill material (clean imported granular TII Specification for Road Works Series 600 Class 6 material) between the sheet pile wall and existing quay wall. Residual impacts will be *negative, non-significant and permanent* as a result of covering the soft silts in the mudflats. In addition, residual impacts will be *positive, slight and permanent* as a result of preventing the uncontrolled debris from further quay wall deterioration from reaching and fouling the mudflats.

8.7 Difficulties Encountered

No difficulties were encountered in the preparation of this Chapter. The ground investigation data, Geotechnical Factual Report, Geotechnical Interpretative Report and Waste Characterisation report, as well as proposed development description, were of sufficient quality to enable the assessment of impacts.

Additionally, three standpipes with dataloggers have just been installed in September 2021 in the area surrounding Plunkett Station and will provide more refined groundwater data that will inform the detailed design of impermeable trench. The results may suggest the omission of the part of the proposed extent of the trench outlined in this EIAR and shown in Figures 4.1 to 4.5 in Volume 3 and will not result in enlarging of the extent of trench.

8.8 References

IGSL (2019) Geotechnical Factual Report, Waterford City Public Infrastructure Project Ground Investigation, project no. 21831

IGSL (2020) Geotechnical Interpretative Report, Waterford City Public Infrastructure Project Ground Investigation, project no. 21831

O'Callaghan Moran & Associates (2020) Waste Characterisation Assessment, North Quay Waterford – Railway

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GeoHive historical mapping: http://map.geohive.ie/, accessed 01/03/2021