REPORT

Millport Coastal Flood Protection Scheme: Environmental Statement

Chapter 18 Water Resources and Flood Risk

Client: North Ayrshire Council

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Acronyms

Acronym	Acronym description
BGS	British Geological Survey
CAR	Controlled Activities Regulations
CIA	Cumulative Impact Assessment
EIA	Environmental Impact Assessment
ES	Environmental Statement
LDP	Local Development Plan
LNR	Local Nature Reserve
GPP	Guidance for Pollution Prevention
NPF	National Planning Framework
PANS	Planning Advice Notes
RIGS	Regionally Important Geological Site
SEPA	Scottish Environment Protection Agency
SAC	Special Areas of Conservation
SNCI	Site of Nature Conservation Interest
SPA	Special Protection Areas
SPP	Scottish Planning Policy
SSSI	Site of Special Scientific Interest

Glossary

Glossary Term	Glossary Text
Environmental Impact Assessment (EIA)	A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the EIA Directive and EIA Regulations, including the publication of an Environmental Statement.
Environmental Statement (ES)	A document reporting the findings of the EIA and produced in accordance with the EIA Directive as transposed into UK law by the EIA Regulations.
Millport Coastal Flood Protection Scheme	The scheme consists of offshore rock armour structures which will be built in the vicinity of the rock islets within Millport Bay. Onshore works will include flood walls, improvement works to existing coast protection structures, and works to raise the level of existing grass areas. Works on the foreshore include shore-connected rock armour breakwaters and rock armour revetments.

18 Water Resources and Flood Risk

18.1 Introduction

1. This chapter of the Environmental Statement (ES) considers the potential impacts of the proposed Millport Coastal Flood Protection Scheme (the proposed scheme) on water resources and flood risk.

2. This chapter provides a summary description of key aspects relating to existing environment followed by an assessment of the magnitude and significance of the effects upon the baseline conditions resulting from the construction, operation and decommissioning of the Proposed Scheme as well as those effects resulting from cumulative interactions with other existing or planned projects.

3. The potential effects on water resources and flood risk are assessed conservatively using realistic worst-case scenarios for the proposed scheme.

4. All figures referred to in this chapter are provided in Volume II of this ES.

5. The assessment of potential effects has been made with specific reference to Scotland's National Planning Framework and Planning Policy. These are discussed further in **Chapter 2 Policy and Legislation** and outlined below in Section 18.2. These are the principal decision-making documents for flood protection schemes.

6. This chapter has been prepared by Royal HaskoningDHV in accordance with the relevant legislation and policies, adhering to the methodology for Environmental Impact Assessment (EIA) and Cumulative Impact Assessment (CIA) as discussed in Section 18.4.

7. Due to the close association between water resources and flood risk with ground conditions and groundwater, intertidal ecology and human health, this chapter should be read in conjunction with **Chapter 17 Ground Conditions and Contamination, Chapter 8 Benthic Ecology** and **Chapter 23 Tourism and Recreation**.

8. Additional information to support the assessment of impacts on groundwater and Kames Bay SSSI receptors is provided separately in **Appendix 18.1 (Volume III): Millport Flood Protection Scheme, North Ayrshire: Groundwater Desk Study.**

18.2 Policy, Legislation and Guidance

9. There are a number of pieces of legislation applicable to water resources and flood risk. The following key pieces of International and UK legislation which are relevant to this chapter. Further details are provided in **Chapter 2 Policy and Legislation** on the following legislation.

10. The policies and plans outlined throughout this section have also been reviewed for their relevance to water resources and flood risk when undertaking the EIA for the proposed scheme.

18.2.1 International Legislation and Policy

11. Table 18-1 below provides a brief summary of the key international legislation and policy relevant to the scheme.

Table 18-1 Summary of key international legislation and policy relevant to this proposed scheme

Legislation	Relevance
Water Framework Directive (2000/60/EC)	Council Directive 2000/60/EC establishing a framework for community action in the field of water policy. requires that all European Union (EU) Member States must prevent deterioration and protect and enhance the status of aquatic ecosystems. This means that EU Member States must ensure that new schemes do not adversely impact upon the status of aquatic ecosystems, and that historical modifications that are already impacting it need to be addressed.
Groundwater Directive (2006/118/EC)	The Groundwater Directive (2006/118/EC) establishes a regime which sets groundwater quality standards and introduces measures to prevent or limit inputs of pollutants into groundwater.

18.2.2 National Legislation and Policy

18.2.2.1 National Legislation

12. Table 18-2 below provides a brief summary of the key national legislation and policy relevant to the scheme.

Table 18-2 Summary of key national legislation and policy relevant to this proposed scheme

Legislation	Relevance
Water Environment and Water Services (Scotland) Act 2003 (WEWS Act)	This arose from the Water Framework Directive 2000/60/EC becoming law in Scotland. It commits Scotland to achieve good qualitative and quantitative status of all water bodies by 2015 with the final deadline for meeting objectives being 2027
Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended)	The Controlled Activities Regulations 2011 (CARs) (and it's amendments in 2013 and 2017) apply regulatory controls over activities which may affect Scotland's water environment. The regulations cover rivers, lochs, transitional waters (estuaries), coastal waters, groundwater and groundwater dependent wetlands.

18.2.2.2 National Planning Policy

National Planning Framework

13. Scotland's third National Planning Framework (NPF) (Scottish Government, 2014a) includes the following ambitions relevant to water quality and flood risk at Millport, and these have been considered when undertaking the EIA for the proposed scheme:

14. *Para 4.3 Scotland has abundant water resources, including iconic lochs and river networks and an extensive canal network, which contribute to the quality and distinctiveness of our environment. Clean, high quality drinking water is vital for quality of life and the success of our food and drink sector.*

15. *Para 4.16 Our urban infrastructure will need to change to adapt to the impacts of climate change. The coastal location of many of Scotland's cities means that land use change may be needed to achieve more sustainable and resilient patterns of development in the long-term. In particular, water management and flooding issues will become increasingly important.*

16. *Para 4.25 Adaptation requirements will need to be wide ranging. Catchment-scale flood risk management will become more important in response to changing weather patterns. Planning authorities have a role to play within cross-boundary and multi-sectoral working. Sustainable land management and ecosystems enhancement provide opportunities for adaptation that delivers benefits for communities, the economy and the wider environment. As they emerge, we expect flood risk management plans to become an integral part of strategic and local development planning.*

Changing water supplies and water quality issues, coastal erosion and increased vulnerability of the historic building stock will also need to be factored into planning decisions over the longer term.

Scottish Planning Policy

17. Scotland's Planning Policy (SPP) (Scottish Government, 2014b) contains the following Policy Principles with regards to Valuing the Natural Environment and these have been taken into consideration when undertaking the EIA for the proposed scheme:

18. The planning system should:

- *Facilitate positive change while maintaining and enhancing distinctive landscape character;*
- *Conserve and enhance protected sites and species, taking account of the need to maintain healthy ecosystems and work with the natural processes which provide important services to communities;*
- ***Promote protection and improvement of the water environment, including rivers, lochs, estuaries, wetlands, coastal waters and groundwater, in a sustainable and co-ordinated way**;*
- *Seek benefits for biodiversity from new development where possible, including the restoration of degraded habitats and the avoidance of further fragmentation or isolation of habitats; and*
- *Support opportunities for enjoying and learning about the natural environment.*

Planning Advice Notes (PANS)

19. *Planning Advice Note (PAN) 1/2013: Environmental Impact Assessment* explains the role of individual planning authorities and that of the Consultation Bodies in EIA, as well as providing guidance on the ways in which EIA can be integrated into the overall development management process.

20. *PAN 79 (2006): Water and Drainage "The purpose of this Planning Advice Note (PAN) is to provide advice on good practice in relation to the provision of water and drainage in a planning context."*

18.2.3 Local Planning Policy

21. The proposed scheme falls within the North Ayrshire Council local authority boundaries.

22. North Ayrshire Council have adopted a new Local Development Plan for North Ayrshire on 28th November 2019 (North Ayrshire Council, 2019), the LDP covers a 20 year period. For the purpose of the Local Plan, Millport and the footprint of the proposed scheme is categorised to be within 'Developed Coast'.

23. The Ayrshire Joint Structure Plan 'Growing A Sustainable Ayrshire' (North Ayrshire Council, East Ayrshire Council and South Ayrshire Council, 2007) establishes a framework that brings together the aspirations of communities with those of business and industry, and the area's many supporting agencies and organisations, to provide a strategic land use context to the year 2025. The Plan classes Great Cumbrae as a 'potential area' for a woodland strategy.

24. Table 18-3 provides details of the local planning policy documents and the relevant policies in respect to Water Resources and Flood Risk. These policy document have been considered when undertaking the EIA for the proposed scheme.

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Table 18-3 Relevant local planning policies

Document	Policy / Guidance	Policy / Guidance purpose	ES Reference
Adopted Local Development Plan (LDP2) (2019)	Strategic Policy 3: Strategic Development Areas	"We will support the development of the Strategic Development Areas… Proposals must demonstrate they do not adversely impact on the environmental quality of North Ayrshire by way of adverse impact on soils, **water**, air, population, human health, cultural heritage, material assets, climatic factors, landscape and biodiversity (flora and fauna)."	Impacts on water quality and quantity are considered in Section 18.6.
	Policy 22: Water Environment Quality	"We will support development that helps achieve the objectives of the Water Framework Directive and the River Basin Management Plan for Scotland. Generally, development which would lead to the deterioration of the water environment will be resisted unless it would deliver significant social, environmental or economic benefits."	Impacts on water quality are considered in Section 18.6.
	Policy 23: Flood Risk Management	"We will support development that demonstrates accordance with the Flood Risk Framework as defined in Scottish Planning Policy and shown in schedule 7, relevant flood risk management strategies and local flood risk management plans. We will also support schemes to manage flood risk, for instance through natural flood management, managed coastal realignment, wetland or green infrastructure creation."	The proposed scheme is designed to manage flood risk.
North Ayrshire Council Environmental Policy, 2012 (North Ayrshire Council, 2012)	Challenge 5	To control all forms of pollution and public health risk by: • Ensuring safe drinking water supplies.	Impacts on water quality are considered in Section 18.6.
Ayrshire Joint Structure Plan (2014)	ENV 1 Landscape Quality	In providing for new development, particular care shall be taken to conserve those features that contribute to local distinctiveness including:	Impacts on the Kames Bay SSSI are considered in Section 18.6.

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Document	Policy / Guidance	Policy / Guidance purpose	ES Reference
		• Special qualities of rivers, estuaries and coasts.	
	ENV 8 Flooding	Development proposals which would be at significant risk of flooding or which would increase the probability of flooding elsewhere will not be permitted.	The proposed scheme is designed to manage flood risk.
	ENV 9 Water Framework Directive	The three Ayrshire councils shall work with other agencies to introduce the Water Framework Directive into Planning Policy.	Noted.

18.2.4 Best Practice and Guidance

25. The impact assessment is based upon the Scottish Environment Protection Agency (SEPA) Guidance for Pollution Prevention (GPPs). The GPPs provide environmental regulatory guidance to Scotland. Relevant to Water Resources is:

- GPP5: Works and maintenance in or near water (Northern Ireland Environment Agency (NIEA), Department for Agriculture the Environment and Rural Affairs (DAERA, SEPA and Natural Resources Wales (NRW), 2018).

18.3 Consultation

26. To inform the ES, North Ayrshire Council has undertaken a thorough pre-application consultation process, which has included the following key stages:

- Scoping Reports submitted to Marine Scotland and North Ayrshire Council (Royal HaskoningDHV 2017); and
- Scoping Opinion received from Marine Scotland and North Ayrshire Council (2017).

27. Full details of the proposed scheme consultation process to date is presented within **Chapter 3 EIA Methodology and Consultation.**

28. A summary of the consultation carried out at key stages throughout the proposed scheme, of particular relevance to water resources and flood risk, is presented in Table 18-4.

Table 18-4 Consultation responses

Consultee	Date/ Document	Comment	Response / Where addressed in the ES
Scottish Environment Protection Agency (SEPA)	19/05/2017 Scoping Report	Supportive of scheme in principle based on FRA (SEPA not consulted on this) and unlikely to object on flooding grounds to any application unless the development differs from that already proposed.	Noted.
		Engineering works proposed are unlikely to require CAR consent based on current design.	Noted.

Consultee	Date/ Document	Comment	Response / Where addressed in the ES
		Comply with PPG Notes during construction	This has been incorporated into embedded mitigation within Section 18.6.3.
		Insufficient information has been provided to scope groundwater . Hydrogeology out of the project. The information in Section 4 does not consider g/w quality and quantity or effects on base flow and groundwater resources. There is mention with in Appendix 4.1 of report of g/w flow and quality but this is limited to hydrocarbon pollution and geotechnical issues. Section 4.4 indicates that Section 5.6 considers groundwater but this is not so.	Impacts on groundwater quality and quantity are assessed in Section 18.6.
		Recommend that a section on g/w is included in ES or that more information is provided to address the omission of these issues in the scoping report to justify why g/w is not being considered.	
		With respect to groundwater related geotechnical risks SEPA has no comment but would advise that any dewatering undertaken may require CAR authorisation.	Dewatering is not currently expected to be required given the limited depth of excavation needed for construction of the onshore works.

18.4 Methodology

29. This section describes the data sources used to inform the assessment of effects of the development on water resources and flood risk.

18.4.1 Baseline Data and Study Area

18.4.1.1 Summary of Study Area

30. The study area is defined by the distance over which impacts on water resources and flood risk from the proposed scheme may occur and by the location of any receptors that might be affected by those potential impacts.

31. The onshore infrastructure for the proposed scheme is detailed in **Chapter 5 Project Description**, and represented in Figure 1-1, in summary it will include:

- Onshore and foreshore works – improvements to coastal defence structures;
- Improvements to existing sea walls;
- New flood wall; and
- Raised ground levels.

18.4.1.2 Data Sources – Desk Study

32. The main sources of baseline data are the following:

- Appendix 18.1, Millport Flood Protection Scheme, North Ayrshire: Groundwater Desk Study; and
- Millport Flood Protection Scheme, North Ayrshire: Geotechnical and Land Contamination Desk Study, Royal HaskoningDHV 2016

18.4.1.3 Data Sources – Site Specific Surveys and Reports

33. The Millport Coastal Flood Protection Scheme 2017 ground investigation was carried out by BAM Ritchies between 18th January and 2nd February 2017 (Royal HaskoningDHV 2017). The purpose of this investigation was to provide geotechnical parameters and contamination assessment to enable design and construction of the proposed developments to be undertaken. This included:

- 4 no. cable percussion boreholes (BH-TP-01 to 04) drilled to depths of up to 2.7m below ground level.
- 8 no. hand dug inspection pits (TP01A, 02A, 7, 13, 13A, 14 to 16) to depths of up to 1.7m below ground level.
- 26 no. machine excavated trial pits (TP5, 6, 8, 9, 17 to 29, TPA, B, C, F, G, H, J, K, L, and TPA, B, C, F, G, H, J, K and L) to depths of up to 2.4m below ground level.
- In situ standard penetration testing (SPTs).
- Hand vane testing.
- Geotechnical and geo-environmental sampling.
- Plate bearing tests.
- Ground water level monitoring and ground water sampling; and
- Geophysical Surveys including (multibeam bathymetric survey, sub bottom profile survey, magnetometer survey, side scan sonar survey and ground penetrating radar survey of the existing pier).

18.4.2 Impact Assessment Methodology

34. General methods for EIA are discussed in **Chapter 3 EIA Methodology and Consultation.** The following sections describe the methodology used to assess the potential impacts of the proposed scheme on water resources and flood risk in more detail.

35. The approach to determining the significance of an impact follows a systematic process for all impacts. This involves identifying, qualifying and, where possible, quantifying the sensitivity, value and magnitude of all receptors which have been scoped into this assessment. Using this information, a significance of each potential impact has been determined. Each of these steps is set out in the remainder of this section.

36. For the impacts on water resources and flood risk a number of discrete receptors can be identified. These include:

- Groundwater (quality and quantity); and
- Kames Bay SSSI

18.4.2.1 Sensitivity, Value, Magnitude

37. The sensitivity and value of discrete receptors and the magnitude of effect are assessed using expert judgement and described with a standard semantic scale. These expert judgements of receptor sensitivity, value and magnitude of effect are guided by the conceptual understanding of baseline conditions.

38. The sensitivity of a receptor (Table 18-5) is dependent upon its:

- Tolerance: the extent to which the receptor is adversely affected by an effect;
- Adaptability: the ability of the receptor to avoid adverse impacts that would otherwise arise from an effect; and
- Recoverability: a measure of a receptor's ability to return to a state at, or close to, that which existed before the effect caused a change.

Table 18-5 Definitions of Sensitivity Levels for Receptors

Sensitivity	Definition
High	Receptor has **very limited** capacity to tolerate changes to hydrology, geomorphology, and water quality or flood risk. *Water resources* Controlled waters with an unmodified, naturally diverse hydrological regime, a naturally diverse geomorphology with no barriers to the operation of natural processes, and good water quality. Supports habitats or species that are highly sensitive to changes in surface hydrology, geomorphology or water quality. Very high productivity bedrock aquifer with public water supply abstractions by provision of recharge. *Flood risk* Most Vulnerable Land Use, as defined by Flood Risk and Land Use Vulnerability Guidance (SEPA 2018). Land with more than 100 residential properties (after Design Manual for Roads and Bridges (DMRB) 2009).
Medium	Receptor has **limited** capacity to tolerate changes to hydrology, geomorphology, and water quality or flood risk. *Water resources* Controlled waters with hydrology that sustains natural variations, geomorphology that sustains natural processes, and water quality that is not contaminated to the extent that habitat quality is constrained. Supports or contributes to habitats or species that are sensitive to changes in surface hydrology, geomorphology and/or water quality. High productivity bedrock aquifer or high productivity superficial aquifer, with water supply abstractions. Site is within a Water Regulation Zone. Surface Water Drinking Water Protected Area Groundwater Drinking Water Protected Area Site is within a Water Regulation Zone. *Flood risk*

Sensitivity	Definition
	Highly Vulnerable Land Use or Least Vulnerable Land Use, as defined by Flood Risk and Land Use Vulnerability Guidance (SEPA 2018). Land with between 1 and 100 residential properties or more than 10 industrial premises (after DMRB 2009).
Low	Receptor has **moderate** capacity to tolerate changes to hydrology, geomorphology, and water quality or flood risk. *Water resources* Controlled waters with hydrology that supports limited natural variations, geomorphology that supports limited natural processes and water quality that may constrain some ecological communities. Supports or contributes to habitats that are not sensitive to changes in surface hydrology, geomorphology or water quality. Supports moderate or low productivity bedrock or superficial aquifer without abstractions. *Flood risk* Essential Infrastructure land use, as defined by Flood Risk and Land Use Vulnerability Guidance (SEPA 2018). Land with 10 or fewer industrial properties (after DMRB 2009).
Negligible	Receptor is **generally** tolerant of changes to hydrology, geomorphology, and water quality or flood risk. *Water resources* Controlled waters with hydrology that does not support natural variations, geomorphology that does not support natural processes and water quality that constrains ecological communities. Aquatic or water-dependent habitats and/or species are tolerant to changes in hydrology, geomorphology or water quality. Very low productivity bedrock aquifer or non-productive strata that does not support groundwater resources. *Flood risk* Water Compatible Land Use, as defined by Flood Risk and Land Use Vulnerability Guidance (SEPA 2018). Land with limited constraints and a low probability of flooding of residential and industrial properties (after DMRB 2009).

39. In addition, a *value* component may also be considered when assessing a receptor (Table 18-6).

Table 18-6 Definitions of the Different Value Levels for Receptors

Value	Definition
High	Receptor is an internationally or nationally important resource with limited potential for offsetting / compensation. *Water resources* Supports or contributes to designated habitats or species of international or national importance (e.g. Special Area of Conservation (SAC), Special Protection Area (SPA), and Site of Special Scientific Interest (SSSI)). Licensed potable abstractions (surface water and groundwater).

Value	Definition
	Flood risk Nationally significant infrastructure. Internationally or nationally designated planning policy areas.
Medium	Receptor is a regionally important resource with limited potential for offsetting / compensation. *Water resources* Supports or contributes to habitats or species of UK regional value (Site of Nature Conservation Interest (SNCI), Regionally Important Geological Site (RIGS)). Licensed non-potable abstractions and unlicensed potable abstractions (surface water and groundwater). *Flood risk* "Locally significant infrastructure". Local planning policy designated sites.
Low	Receptor is a locally important resource. *Water resources* Supports or contributes to habitats or species of local value (e.g. Local Nature Reserve (LNR)). Unlicensed non-potable abstractions (surface water and groundwater). *Flood risk* Drainage that does not discharge to Critical Drainage Areas.
Negligible	Receptor is not considered to be an important resource.

Magnitude

40. The magnitude of the impact is assessed according to:

- The extent of the area subject to a predicted impact;
- The duration the impact is expected to last prior to recovery or replacement of the resource or feature;
- Whether the impact is reversible, with recovery through natural or spontaneous regeneration, or through the implementation of mitigation measures or irreversible, when no recovery is possible within a reasonable timescale or there is no intention to reverse the impact; and
- The timing and frequency of the impact, i.e. conflicting with critical seasons or increasing impact through repetition.

41. Table 18-7 summarises the definitions of magnitude that have been used for the receptors.

Table 18-7 Definitions of magnitude levels

Magnitude	Definition
High	Fundamental, permanent / irreversible changes, over the whole receptor, and / or fundamental alteration to key characteristics or features of the particular receptors character or distinctiveness. *Water resources* Permanent changes to geomorphology and/or hydrology that prevent natural processes operating. Permanent and/or wide scale effects on water quality or availability.

Magnitude	Definition
	Permanent loss or long-term (>5 years) degradation of a water supply source resulting in prosecution. Permanent or wide scale degradation of habitat quality. *Flood risk* Permanent or major change to existing flood risk. Reduction in on-site flood risk by raising ground level in conjunction with provision of compensation storage. Increase in off-site flood risk due to raising ground levels without provision of compensation storage. Failure to meet either sequential or exception test (if applicable).
Medium	Considerable, permanent / irreversible changes, over the majority of the receptor, and / or discernible alteration to key characteristics or features of the particular receptors character or distinctiveness. *Water resources* Medium-term (1-5 years) effects on water quality or availability. Medium-term (1-5 years) degradation of a water supply source, possibly resulting in prosecution. Habitat change over the medium-term (1-5 years). *Flood risk* Medium-term (1-5 years) or moderate change to existing flood risk. Possible failure of sequential or exception test (if applicable). Reduction in off-site flood risk within the local area due to the provision of a managed drainage system.
Low	Discernible, temporary (throughout project duration) change, over a minority of the receptor, and / or limited but discernible alteration to key characteristics or features of the particular receptors character or distinctiveness. *Water resources* Short-term (<1 year) or local effects on water quality or availability. Short-term (<1 year) degradation of a water supply source. Habitat change over the short-term. *Flood risk* Short-term (<1 year), temporary or minor change to existing flood risk. Localised increase in on-site or off-site flood risk due to increase in impermeable area. Passing of sequential and exception test.
Negligible / No Impact	Discernible, temporary (for part of the project duration) change, or barely discernible change for any length of time, over a small area of the receptor, and/or slight alteration to key characteristics or features of the particular receptors character or distinctiveness. *Water resources* Intermittent impact on local water quality or availability. Intermittent or no degradation of a water supply source. Very slight local changes to habitat that have no observable impact on dependent receptors. *Flood risk* Intermittent or very minor change to existing flood risk.

Magnitude	Definition
	Highly localised increase in on-site or off-site flood risk due to increase in impermeable area.

18.4.2.2 Impact Significance

42. Following the identification of receptor importance and magnitude of the effect, it is possible to determine the significance of the impact.

43. Impacts are unlikely to be significant where features of low importance are subject to small scale or short-term effects. If an impact is found not to be significant at the level at which the resource or feature has been valued, it may be significant at a more local level.

44. Following the identification of receptor importance and magnitude of effect, the significance of the impact has been considered using the matrix presented in Table 18-8 below and knowledge of the ecological features affected.

45. The assessment of potential impacts has been undertaken assuming implementation of embedded mitigation and commitments for the proposed scheme. Residual impacts include any additional mitigation measures required. An assessment of residual impacts is then made, after assuming implementation of additional mitigation measures where required, i.e. the significance of the effects that are predicted to remain after the implementation of all committed mitigation measures.

Table 18-8 Impact significance matrix

		Negative Magnitude				Beneficial Magnitude			
		High	Medium	Low	Negligible	Negligible	Low	Medium	High
Sensitivity	High	Major	Major	Moderate	Minor	Minor	Moderate	Major	Major
	Medium	Major	Moderate	Minor	Minor	Minor	Minor	Moderate	Major
	Low	Moderate	Minor	Minor	Negligible	Negligible	Minor	Minor	Moderate
	Negligible	Minor	Minor	Negligible	Negligible	Negligible	Negligible	Minor	Minor

46. The impact significance categories are defined as shown in Table 18-9.

Table 18-9 Impact significance definitions

Impact Significance	Definition
Major	Very large or large change in receptor condition, both adverse or beneficial, which are likely to be important considerations at a regional or district level because they contribute to achieving national, regional or local objectives, or, could result in exceedance of statutory objectives and / or breaches of legislation.
Moderate	Intermediate change in receptor condition, which are likely to be important considerations at a local level.
Minor	Small change in receptor condition, which may be raised as local issues but are unlikely to be important in the decision making process.
Negligible	No discernible change in receptor condition.
No Change	No impact, therefore no change in receptor condition.

47. Note that for the purposes of the EIA, major and moderate impacts are deemed to be significant. In addition, whilst minor impacts are not significant in their own right, it is important to distinguish these from other non-significant impacts as they may contribute to significant impacts cumulatively or through interactions.

48. Embedded mitigation has been referred to and included in the initial assessment of impact. If the impact does not require mitigation (or none is possible) the residual impact remains the same. However, if mitigation is required, an assessment of the post-mitigation residual impact is provided.

49. For the purposes of this ES, ‘major’ and ‘moderate’ impacts are deemed to be significant (in EIA terms). In addition, whilst ‘minor’ impacts may not be significant, it is important to distinguish these from other non-significant (negligible) impacts as they may contribute to significant impacts cumulatively.

50. Following initial assessment, if the impact does not require additional mitigation (or none is possible) the residual impact will remain the same. If, however, additional mitigation is proposed there will be an assessment of the post-mitigation residual impact.

18.4.2.3 Cumulative Impact Assessment

51. For an introduction to the methodology used for the Cumulative Impact Assessment (CIA), please refer to **Chapter 3 EIA Methodology and Consultation**. This chapter includes those cumulative impacts that are specific to water resources and flood risk.

52. The CIA involves consideration of whether impacts on a receptor can occur on a cumulative basis between the Project and other activities, projects and plans for which sufficient information regarding location and scale exist.

53. The potential for cumulative effects has been considered for the construction, operation and decommissioning of the proposed scheme cumulatively with other projects.

54. It is assumed that any consented development would be subject to mitigation and management measures which would reduce impacts to non-significant unless there were exceptional

circumstances, it is accepted that such projects or schemes may contribute to a wider cumulative impact.

55. In cases where this proposed scheme has negligible or no impact on a receptor (through for example avoidance of impact through routeing or construction methodology) it is considered that there is no pathway for a cumulative impact.

18.5 Existing Environment

56. This section describes the existing environment in relation to water resources and flood risk. Appendix 18.1, the Millport Flood Protection Scheme, North Ayrshire: Groundwater Desk Study, the Geotechnical and Land Contamination Desk Study, (Royal HaskoningDHV, 2016) (completed as part of the Scoping Report) and Ground Investigation Report (Royal HaskoningDHV, 2017), form the basis of the baseline environmental information that was utilised to assess the environmental impacts associated with the proposed scheme.

18.5.1 Overview

57. The island of Great Cumbrae is located in the Firth of Clyde about 1.5km from the mainland. The majority of the coast of the island is characterised by an emergent rock platform, with isolated pocket bays containing beaches. The rock foreshore is currently stable with low rates of change. Millport Bay is the part of the island coast that contains larger lengths of mobile beach sediment. The bay can be divided into three parts:

- Kames Bay located in the northeast corner of Millport which contains a 150m-wide sandy beach;
- A sandy beach (about 50m wide) on rock platform at Newtown Bay; and
- The rest of the Millport shore, which has a sand and gravel veneer overlying rock platform.

58. Millport Bay faces south, with Kames Bay (at the eastern end) aligned to the south-southwest. Within the bay, there are large rock outcrops, known as the Eileans, the Leug and the Spoig, which provide shelter to the central section of Millport Bay against waves from the south. The shelter provided by these outcrops has led to the deposition of sand in their lee along the Newtown Bay shoreline (i.e. forming a small salient).

18.5.2 Geology

59. Some made ground is expected along roadsides and the waterfront. The British Geological Survey Geology of Britain viewer (BGS, 2019) indicates that superficial deposits overlie sedimentary rock strata of Carboniferous age with igneous intrusions of Carboniferous and Palaeogene age. A north-south trending fault is present at the eastern end of Kames Bay, where the headland is formed by outcropping rock strata of Devonian age. Other significant rock outcrops at the site include Bessy's Port, Long Point and the island group known as "The Eileans".

60. The British Geological Survey Geology of Britain viewer (BGS, 2018) holds no borehole records in the vicinity of Millport. The anticipated stratigraphy at the site in order of superposition is summarised in Table 18-10.

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Table 18-10 Summary of published geology

Age	Name	Description
Pleistocene and Holocene (Quaternary)	Glacial Till	Moraines of till with outwash sand and gravel deposits.
	Raised Marine Deposits	Sand and gravel.
	Marine Beach Deposits	Sand and gravel.
Palaeogene	Mull Dyke-swarm	Microgabbro.
Carboniferous	Dinantian Dykes	Microgabbro.
	Millport Cornstones Member	Grey sandstone and red-brown silty mudstone with pedogenic limestone.
	Ballagan Formation	Grey mudstones and siltstones, with nodules and beds of ferroan dolomite (cementstones), the beds generally less than 0.3m thick. Gypsum and, to a much lesser extent, anhydrite and pseudomorphs after halite occur.
	West Bay Cornstone Member	Sandstone and nodular limestone (cornstone).
Devonian	Kelly Burn Sandstone Formation	Mainly red, cross-bedded, pebbly sandstone with subordinate conglomerate beds.

61. Glacial till is present inland of Millport and thus it may be present between the marine beach deposits and the rockhead. The ground investigation undertaken by Royal HaskoningDHV in 2017 confirmed the ground conditions with the study area generally comprise Made Ground overlying marine deposits overlying bedrock (Royal HaskoningDHV, 2017).

18.5.3 Hydrology

62. There is a small watercourse (Mill Burn) which flows into the West Bay area of Millport from the north (via Mid Kirkton and Nether Kirkton). The Mill Burn is culverted through the town.

63. There is another small watercourse which flows from the north and emerges onto Kames Bay from a culvert. An Admiralty chart shows dated 1846 (Hydrographic Office of the Admiralty, 1852) shows the watercourse running in a north south direction and discharging into “Kames Bay”. There is a “Mill” adjacent to the watercourse approximately 100 m to the north of high water at the bay. This supports our understanding that the watercourse is a heavily modified natural feature, rather than a surface water drain from the built-up area of Kames Bay.

64. As the burns are culverted there is no mechanism for impact by the proposed scheme therefore these will not be considered further within this assessment.

18.5.4 Hydrogeology

65. It is assumed that groundwater flow in the vicinity of the town of Millport is likely to be dominated by flow from the centre of the island radially towards the coast. More locally, the flow is likely to be modified by the presence of dykes and faults, and also structures such as quay walls. Groundwater levels, particularly close to the coast, are likely to be tidally influenced.

66. A number of wells are recorded between 50 m and 100 m inland of the high-water mark within the town of Millport:

- Two are recorded adjacent to what is now known as College Street approximately 80m and 100m north of Glasgow Street,
- Four are recorded at the very rear of the gardens of properties on Stuart Street and Guildford Street, immediately next to what is now known as Howard Street; and
- Four are recorded in the gardens of properties on Glasgow Street.

67. This suggests that the Millport Cornstone Member, and possibly the Ballagan Formation, have some degree of conductivity although it is not known whether this is predominantly primary (i.e. intergranular) or secondary (i.e. via fracture flow). It also suggests that the groundwater close to the shore is relatively fresh.

18.5.5 Water Quality

68. There are no surface water, Water Framework Directive Classifications on Great Cumbrae, however offshore, the Largs Channel (Fairlie Roads) coastal water body (Reference ID: 200026) is classed as 'Good' (SEPA, 2018).

69. The groundwater Water Framework Directive Classification on Great Cumbrae (Reference ID: 150440) is 'Good' (SEPA, 2018). The groundwater below Millport (excluding Kames Bay and other beach areas) is classed as a 'Water Regulation Zone', which represents the extent of the area supplied by Scotland's water authority, as represented on the Scottish Government's data viewer (Scottish Government, 2018). The majority of Great Cumbrae is also a Ground Water Protected Area (Scottish Government, 2018), which area areas defined by the Scottish Environment Protection Agency in line with the requirements of The Water Environment (Drinking Water Protected Areas) (Scotland) Order 2013.

18.5.6 Kames Bay Site of Special Scientific Interest (SSSI)

70. The most sensitive receptor within the study area with respect to the quality of groundwater is the Kames Bay Site of Special Scientific Interest (SSSI). Whilst the flora and fauna of Kames Bay are not understood to be unique or threatened, it is considered to be a classic Scottish site for the study of inter-tidal marine biology, having contributed more to the understanding of marine biology than any other stretch of beach in Scotland. This largely results from the proximity of the University Marine Biological Station (now the Millport Field Studies Council centre) established in 1896.

18.5.7 Flood Risk

71. There is high coastal flood risk in Kames Bay and adjacent to the Millport coastline, as shown in Figure 18-1. There are only three minor areas of High likelihood surface water flooding areas close to Ninian Street (north of Kames Bay), there is a larger area of High likelihood surface water flooding north of Provost's Loan in the fields, but this is localised to that area, this area has a Medium likelihood of surface water flooding around the perimeter. According to SEPA, the definition of High likelihood flooding is "a flood event is likely to occur in the defined area on average once in every ten years (1:10), or a 10% chance of happening in any one year" and Medium likelihood is "a flood event is likely to occur in the defined on average once in every two hundred years (1:200), or a 0.5% chance of happening in any one year". These surface water flooding areas are north of the proposed scheme and will not be impacted by the proposed scheme.

72. As a flood protection scheme, the primary outcome of the works will be to considerably reduce the risk of flooding. The impacts of the works on reduction of coastal flood risk are all strongly positive (i.e. flood risk is reduced), therefore flooding has not been considered further within this assessment.

18.5.8 Anticipated Trends in Baseline Conditions

18.5.8.1 Surface Waters

73. According to Scottish Natural Heritage it is expected that Scotland will have warmer, wetter winters, hotter drier summers and more extreme weather events (Scottish Natural Heritage, 2019). This could result in a change to the hydrology of the surface drainage network including higher winder flows and lower summer flows and an increased number of storm-related flood events. The risk of flooding will be increased as a result of the predicted increase in rainfall and peak river flows. There may also be a higher frequency of extreme summer low flow events which is likely to lead to increases in demand for water resources, such as for crop irrigation (SEPA, 2019).

18.5.8.2 Groundwater

74. Changes in surface water supply is likely to modify patters in groundwater recharge (BGS, 2019). One paper by Herrera-Pantoja and Hiscockon (2008) on the potential changes in groundwater recharge in relation to climate change predicted that under the 'high' gas emissions scenario there would be a potential decrease in groundwater recharge by 7% for Paisley by the end of the century. In addition, a decreased supply of water during the summer and autumn months is likely to result in a higher demand for water from groundwater during these months (SEPA, 2019).

18.6 Impact Assessment

18.6.1 Overview of Potential Impacts

75. Following the methodology presented in Section 18.4 above, the impacts associated with the water resource and flood risk receptors have been assessed and are presented in this section. Where measures over and above the embedded mitigation described in Section 18.6.3 are required to avoid, reduce, remedy/compensate or enhance the adverse impacts of the proposed scheme, this information has been provided.

18.6.2 Worst Case Scenario

76. Table 18-11 identifies those realistic worst-case parameters of the onshore infrastructure that are relevant to water resources and flood risk. Please refer to **Chapter 5 Project Description** for more detail regarding specific activities, and their durations, which fall within the construction phase and refer to Figure 1-1 for the proposed scheme layout.

Table 18-11 Worst case parameters values

Impact	Parameter
Construction	
Impacts to groundwater quality Impacts to groundwater quantity Impacts to the Kames Bay SSSI (through changes in groundwater quality and quantity)	Potential changes in infiltration due to: • Excavation of beach materials (Millburn Street and Crichton Street junction); • Excavation of masonry revetment and beach excavation at Cross House and Crichton Street; • Excavation of footpath along Marine Parade, West Bay Road and Crichton Street and existing road along Millburn Street; • Excavation for foundation of flood walls (up to 1.5m deep and 3m wide); • Excavation of the promenade along Glasgow Street and Kames Bay; • Drilling of rock foreshore to install steel rods (adjacent to Crichton Street and Clyde Street);

Impact	Parameter
	• Removal of existing grass and topsoil along Glasgow Street, adjacent to Kelburn Street and around Kames Bay; and • Potential for break out of some bedrock for the foundation of the flood wall.
Operation	
Impacts to groundwater quality Impacts to groundwater quantity Impacts to the Kames Bay SSSI (through changes in groundwater quality and quantity)	Potential changes in infiltration due to: • New flood wall foundations up to 1.5m deep and 2m wide along Glasgow Street and Crichton Street • Improvements to existing sea walls with up to 2m deep foundations along West Bay Road, and Millburn Street and Marine Parade (east of Kames Bay). • New concrete stepped terrace around Kames Bay, with foundation up to 1m deep. • Raising of existing grass areas by up to 1.2m along Glasgow Street, Kelburn Street and around Kames Bay.
Decommissioning	
As a flood prevention scheme, the Proposed Scheme is anticipated to be maintained rather than removed, and therefore decommissioning activities are currently unknown.	

18.6.3 Embedded Mitigation

18.6.3.1 Scheme Design

Embedding mitigation into the proposed scheme design is a type of primary mitigation and is an inherent aspect of the EIA process. A full account of embedded mitigation measures is contained in ***Chapter 5 Project Description.*** *Where embedded mitigation measures have been developed into the design of the proposed scheme with specific regard to water resources and flood risk, these are described in Table 18-12. Additional mitigation measures are also included to follow best practice and policy requirements. These mitigation measures are described in*

77. Table 18-13.

Table 18-12 Embedded mitigation measures within the scheme design

Parameter	Mitigation measures embedded into the scheme design
Footprint	Localised reduction of the width of the Proposed Working Area where practical
Drainage	Drainage through and/or past the crest walls will be included in the design, by adding new drainage gullies, scupper holes through the crest walls, and/or adjusting falls and levels of hard surfaces to maintain drainage flow paths. Drainage over the stepped terrace to Kames Bay, rather than through a flood wall. Drainage through and/or past the raised areas will be included in the design, by adding new drainage gullies and/or adjusting falls and levels of hard surfaces to maintain drainage flow paths.
Consultation	Ongoing consultation with local community and other relevant stakeholders

Table 18-13 Embedded mitigation through Best Practice and Policy

Parameter	Mitigation measures through Best Practice and Policy
Follow Guidance for Pollution Prevention 5: Works and maintenance in or near water	The Guidance for Pollution Prevention 5: Works and maintenance in or near water will be followed in order to prevent impacts on the water environment during construction.
General best practice, to be specified in Construction Environmental Management Plan (CEMP)	Construction methodology to minimise potential requirement for dewatering. Store oils and fuel within designated areas above ground in impervious storage bunds with a minimum of 110 % capacity to contain any leaks or spillages. Carry out regular inspections of oil and fuel storage areas. Restrict refuelling activities to designated areas were impermeable surfaces and drip trays are utilised. Have spill kit available for use on site always. All staff to have site inductions were appropriate use of chemical and fuels on site are discussed. A pollution prevention plan and incident response plan will be incorporated into the environmental management plan. This is to be agreed with SEPA and follow industry best practice. Storage of hazardous materials will be done with due care and if adequate store locations cannot be identified within the site compound, these materials will be stored off-site in a secure location. A protocol for dealing with potentially contaminated materials will be utilised during the construction works.

18.6.4 Potential Impacts during Construction

78. This section discusses the potential impacts which may occur to water resources receptors during activities associated with the construction of the proposed scheme. Impacts to marine water and sediment quality are considered in **Chapter 7 Marine Water and Sediment Quality**. Impacts to terrestrial ecology are considered in **Chapter 16 Terrestrial Ecology**. Impacts on ground conditions and contamination are considered in **Chapter 17 Ground Conditions and Contamination.**

79. Four potential impacts on groundwater and Kames Bay SSSI receptors resulting from the construction and operation stage have been identified. These are:

80. Construction:

- Impacts on groundwater quality and Kames Bay SSSI; and
- Impact on groundwater quantity and Kames Bay SSSI.

81. Operation:

- Impact on groundwater quality and Kames Bay SSSI due to flood protection structures; and
- Impact on groundwater quantity and Kames Bay SSSI due to flood protection structures.

18.6.4.1 Construction Impact 1: Impacts on groundwater quality and Kames Bay SSSI

82. Excavations could lead to saline intrusion of the groundwater if there is seawater overtopping during excavations. As discussed in the Millport Groundwater Desk Study (Royal HaskoningDHV, 2018), any significant changes to the salinity of groundwater seeping into the sands of Kames Bay have the potential to shift the distribution of the various studied species and thereby disturb the designated features of the SSSI. Work published in 1955 identified the variation of salinity of pore water in the sand as being key to the distribution of the bristle worm *Nereis diversicolor* at Kames Bay (Smith, 1955). However, it is unlikely that pulses of saline water resulting from low-frequency flood events, contribute significantly to the prevailing salinity of the pore water on the beach (Royal HaskoningDHV, 2018).

83. Construction activities which disturb the ground (including excavations) could potentially introduce contaminants into the underlying groundwater bodies (particularly shallow aquifers). These activities could therefore affect the quality of the underlying groundwater. This has been assessed in **Chapter 17 Ground Conditions and Contamination**.

*The sensitivity of the groundwater is considered to be **high** as it has the potential to affect the designated features of the Kames Bay SSSI. Saline intrusion is predicted to be of local spatial extent, of intermittent duration (related to the working areas only), of intermittent occurrence and high reversibility. With implementation of the embedded mitigation measures within Table 18-12 and*

84. Table 18-13 the magnitude of effect is considered to be **negligible**. Therefore, the potential impact to groundwater quality from saline intrusion is considered to be **minor adverse** and is unlikely to impact on the Kames Bay SSSI .

18.6.4.2 Construction Impact 2: Impact on groundwater quantity and Kames Bay SSSI.

85. Excavations could lead to an increase in infiltration to groundwater during construction activities. This could subsequently lead to an increase in groundwater discharge into Kames Bay SSSI during construction.

*The sensitivity of the groundwater is considered to be **high** as it has the potential to affect the designated features of the Kames Bay SSSI. The potential increase in infiltration is predicted to be of local spatial extent, of intermittent duration (related to the working areas only), of intermittent occurrence and high reversibility. With implementation of the embedded mitigation measures within Table 18-12 and*

86. Table 18-13 the magnitude of effect is considered to be **negligible**. Therefore, the potential impact to groundwater quantity is considered to be **minor adverse** and is unlikely to impact on the Kames Bay SSSI .

18.6.5 Potential Impacts during Operation

18.6.5.1 Operation Impact 1: Impact on groundwater quality and Kames Bay SSSI due to flood protection structures

87. Currently, in the centre of Millport, overtopping of seawater primarily drains away through the town's sewerage network and through overland flow back into the bay. However, the area along Glasgow Street, adjacent to Kelburn Street and around Kames Bay is currently a grass area which has the potential for seawater infiltration to groundwater, following overtopping (Royal HaskoningDHV, 2018). Raising of the grass area will involve earth fill material placed to the appropriate level and compacted if necessary and topsoil will be placed over this fill material. This has the potential to change rate of saline recharge to the groundwater as the fill material will be more densely compacted than the current material and would therefore lead to a decreased rate of infiltration.

88. Although the residence time for groundwater upgradient of Kames Bay is unknown, the likely high permeability of the shallow subsurface suggests that any pulses of saline water resulting from low-frequency flood events would be short lived and unlikely to contribute significantly to the prevailing salinity of the pore water on the beach. The extent to which the species of interest at Kames Bay dominate due to ability to survive in intermittently saline conditions is unknown (Royal HaskoningDHV, 2018).

89. The sensitivity of the groundwater is considered to be **high** as it has the potential to affect the designated features of the Kames Bay SSSI. As the contribution of saline water from low-frequency flood events it unlikely to contribute significantly to the prevailing salinity of the pore water at Kames Bay, it is unlikely that there will be an observable impact on the Kames Bay SSSI, therefore the magnitude of effect is considered to be **negligible**. Overall the impact to groundwater quality and Kames Bay SSSI is considered to be **minor adverse**.

18.6.5.2 Operation Impact 2: Impact on groundwater quantity and Kames Bay SSSI due to flood protection structures

90. As discussed above in Section 18.6.5.1 raising the grass area around Kames Bay with earth fill material has the potential to reduce the infiltration rate into the groundwater. However, as discussed in Section 18.6.3, drainage through and/or past the raised areas will be included in the design, by adding new drainage gullies and/or adjusting falls and levels of hard surfaces to maintain drainage flow paths.

91. The sensitivity of the groundwater is considered to be **high** as it has the potential to affect the designated features of the Kames Bay SSSI. However, following the embedded mitigation measures built into the scheme design, it is not predicted that there will be a change in the discharge rate into groundwater, therefore the magnitude will be **negligible**. Overall the impact to groundwater quantity and Kames Bay SSSI is considered to be **minor adverse**.

18.6.6 Potential Impacts during Decommissioning

92. The structures forming the coastal flood prevention scheme would be designed to have a life of at least 50 years. As the purpose of the proposed scheme is for flood protection, it is unlikely that it would be decommissioned entirely; it is more likely that the scheme would be repaired, or sections replaced or improved if needed in the future. No decision has been made regarding the final decommissioning policy for the offshore infrastructure of the proposed scheme as it is recognised that industry best practice, rules and legislation change over time.

93. The detail and scope of the decommissioning works will be determined by the relevant legislation and guidance at the time of decommissioning and agreed with the regulator. As discussed in **Chapter 5 Project Description**, a decommissioning plan will be submitted for approval by the regulatory authorities prior to construction. As such, impacts no greater than those identified for the construction phase are expected for the decommissioning phase.

18.7 Cumulative Impact Assessment

94. The only project which could cause cumulative impacts with the proposed scheme is the Mill Burn Flood Scheme which currently includes two options for diverting and upgrading the existing Mill Burn culvert. However, this scheme is due to be completed at the latest before Summer 2021, with the

Millport Flood Protection Scheme due to begin construction in Autumn 2021, so unless there is a change to the Mill Burn programme, these schemes will not overlap.

18.8 Inter-relationships

95. Table 18-14 lists out the inter relationships between other chapters within the ES.

Table 18-14 Inter-topic relationships

Topic	Related Chapter	Where addressed in this chapter	Rationale
Impact on groundwater quality and Kames Bay SSSI	Chapter 17 Ground Conditions and Contamination	Section 18.6.4.1	Any impact on the groundwater from mobilisation of contaminants during excavations could impact on the quality of the groundwater.
	Chapter 8 Benthic Ecology		Impacts on the groundwater quality could impact on the intertidal ecology of Kames Bay SSSI.
Impact on groundwater quantity and Kames Bay SSSI.	Chapter 8 Benthic Ecology	Section 18.6.4.2	Impacts on the groundwater quantity could impact on the intertidal ecology of Kames Bay SSSI.
Impact on groundwater quality and Kames Bay SSSI due to flood protection structures	Chapter 8 Benthic Ecology	Section 18.6.5.1	Impacts on the groundwater quality could impact on the intertidal ecology of Kames Bay SSSI.
Impact on groundwater quantity and Kames Bay SSSI due to flood protection structures	Chapter 8 Benthic Ecology	Section 18.6.5.2	Impacts on the groundwater quantity could impact on the intertidal ecology of Kames Bay SSSI.

18.9 Interactions

96. The impacts identified and assessed in this chapter have the potential to interact with each other, which could give rise to synergistic impacts as a result of that interaction. The worst case impacts assessed within this chapter take these interactions into account and for the impact assessments are considered conservative and robust. For clarity, the areas of interaction between impacts are presented in Table 18-15 along with an indication as to whether the interaction may give rise to synergistic impacts.

Table 18-15 Potential interactions between impacts

Potential interaction between impacts		
Construction		
	1 Impact on groundwater quality and Kames Bay SSSI	2 Impact on groundwater quantity and Kames Bay SSSI.

1 Impact on groundwater quality and Kames Bay SSSI		Yes
2 Impact on groundwater quantity and Kames Bay SSSI.	Yes	
Operation		
	1 Impact on groundwater quality and Kames Bay SSSI due to flood protection structures	2 Impact on groundwater quantity and Kames Bay SSSI due to flood protection structures
1 Impact on groundwater quality and Kames Bay SSSI due to flood protection structures		Yes
2 Impact on groundwater quantity and Kames Bay SSSI due to flood protection structures	Yes	

18.10 Summary

97. The main potential impacts of the proposed scheme on groundwater and Kames Bay SSSI receptors have been identified.

98. Two potential impacts during construction and two potential impacts during operation have been identified.

99. A summary of the potential impacts and proposed mitigation is presented in Table 18-16.

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Table 18-16 Potential Impacts Identified for Water Resources and Flood Risk

Potential Impact	Receptor	Value	Magnitude	Significance	Examples of Potential Mitigation Measures	Residual Impact
Construction						
Impact 1: Impacts on groundwater quality and Kames Bay SSSI	Groundwater and Kames Bay SSSI	High	Negligible	Minor adverse (not significant)	N/A	Minor adverse (not significant)
Impact 2: Impact on groundwater quantity and Kames Bay SSSI	Groundwater and Kames Bay SSSI	High	Negligible	Minor adverse (not significant)	N/A	Minor adverse (not significant)
Operation						
Impact 1: Impact on groundwater quality and Kames Bay SSSI due to flood protection structures	Groundwater and Kames Bay SSSI	High	Negligible	Minor adverse (not significant)	N/A	Minor adverse (not significant)
Impact 2: Impact on groundwater quantity and Kames Bay SSSI due to flood protection structures	Groundwater and Kames Bay SSSI	High	Negligible	Minor adverse (not significant)	N/A	Minor adverse (not significant)
Decommissioning						
As a flood prevention scheme, the Proposed Scheme is anticipated to be maintained rather than removed, and therefore decommissioning activities are currently unknown. This will be assessed at the time of any decommissioning activities required.						

18.11 References

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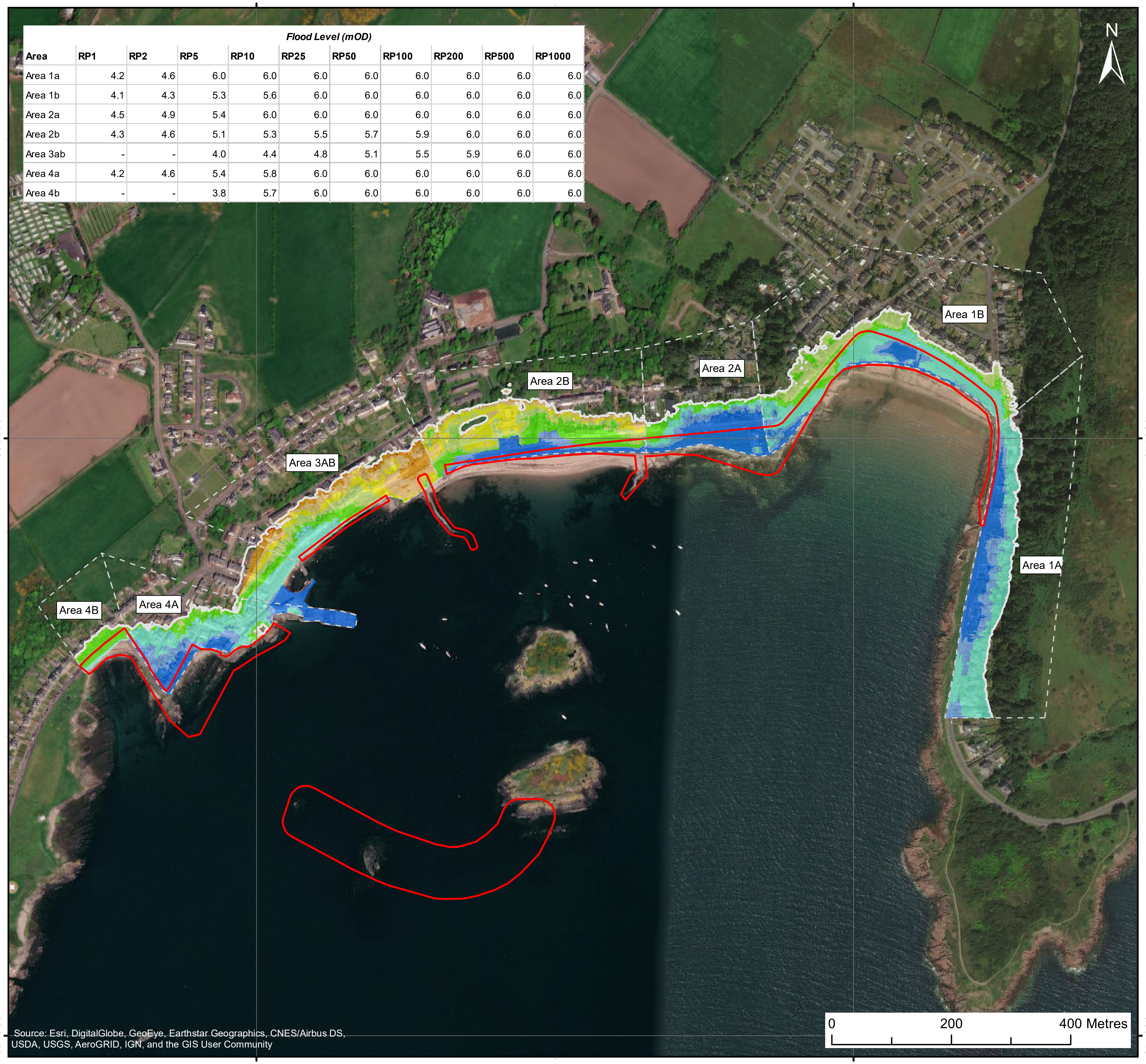
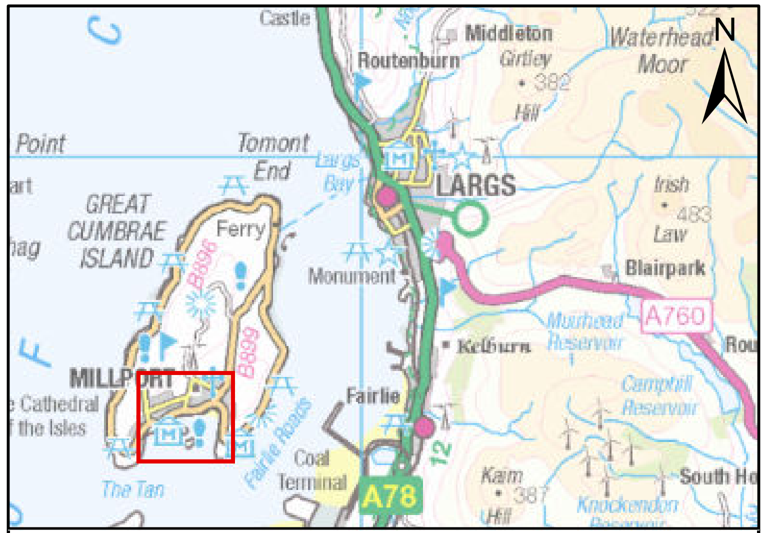
					Flood Level (mOD)					
Area	RP1	RP2	RP5	RP10	RP25	RP50	RP100	RP200	RP500	RP1000
Area 1a	4.2	4.6	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Area 1b	4.1	4.3	5.3	5.6	6.0	6.0	6.0	6.0	6.0	6.0
Area 2a	4.5	4.9	5.4	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Area 2b	4.3	4.6	5.1	5.3	5.5	5.7	5.9	6.0	6.0	6.0
Area 3ab	-	-	4.0	4.4	4.8	5.1	5.5	5.9	6.0	6.0
Area 4a	4.2	4.6	5.4	5.8	6.0	6.0	6.0	6.0	6.0	6.0
Area 4b	-	-	3.8	5.7	6.0	6.0	6.0	6.0	6.0	6.0





Legend

- Redline Boundary
- Assumed maximum flood extent
- Model Areas
- 1yr Flood Extent
- 2yr Flood Extent
- 5yr Flood Extent
- 10yr Flood Extent
- 25yr Flood Extent
- 50yr Flood Extent
- 100yr Flood Extent
- 200yr Flood Extent
- 500yr Flood Extent
- 1000yr Flood Extent

Client:	Project:
North Ayrshire Council	Millport Flood Protection Scheme - EIA Report

Title:

Flood Risk Areas
Baseline

Figure: 18.1	Drawing No:				
Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	06/01/2020	TC	AS	A3	1:6,500

Co-ordinate system: British National Grid

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REPORT

Millport Coastal Flood Protection Scheme: Environmental Statement

Appendix 18.1 Groundwater Desk Study

Client: North Ayrshire Council

Reference: PB4749-RHD-ZZ-XX-RP-Z-00018.1

Status: Final/F01

Date: 31 January 2020

HaskoningDHV UK Ltd.
Industry & Buildings

Note / Memo

To:	Amy Savage
From:	Paul Howlett
Date:	02 May 2018
Copy:	Kerrie Craig
Our reference:	PB4749 xxx
Classification:	Internal use only

Subject: **Millport Flood Protection Scheme, North Ayrshire: Groundwater Desk Study**

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1 Introduction

Millport is the main settlement on the island of Great Cumbrae, which is located in the Firth of Clyde, approximately 2.5km to the west of Largs, on the mainland coast of North Ayrshire. Millport is located at the southern end of the island, within a bay approximately 1.4km in width. Millport town is largely built within a narrow coastal strip, with properties generally located to the landward side of the coastal road.

In July 2015 RHDHV carried out an appraisal of coastal flood risk management options for Millport for North Ayrshire Council (Royal HaskoningDHV, 2015). The location of the study area for that original appraisal is shown in
Figure 1-1, below:

Figure 1-1 - Study Area

The appraisal of coastal flood risk management options for Millport concluded that:

- Millport is at risk from flooding due to overtopping of the existing flood defences. Overtopping occurs due to wave action during storms originating to the south or south west within the Firth of Clyde.
- The relatively steep slope of the coastal frontage means that flood water does not propagate far inland, and water is able to drain away to sea.
- If nothing is done to provide improved protection to 845 residential and commercial properties in Millport, flooding and erosion would cause serious economic damage through the loss of the coastal roads and adjacent residential and commercial properties.
- In economic terms, the flood and erosion damage losses in Millport will exceed £44 million, at current prices, over the next 100 years.

A technical note was prepared to review available published information on the geology and ground conditions at the site, to review historical land use, to review the geotechnical and land contamination risks associated with the proposed improvements and to recommend a scope of ground investigation sufficient to enable the design (Royal HaskoningDHV, 2016).

Following completion of the recommended ground investigation, and further refinement of the design of the proposed improvements, a geotechnical and land contamination assessment was completed (Royal HaskoningDHV, 2017).

In May 2017 SEPA responded to an EIA scoping report. The response advised that:
"It is our view that insufficient information has been provided with the Scoping Report to support scoping groundwater/ hydrogeology out of further stages of the project development as has been indirectly proposed. For example, the 'existing environment' and 'identification of key issues' sections in Section 4 do not consider groundwater quality and quantity, any effects on baseflow and effects on groundwater resources."
and

"The hydrogeology section does not characterise the wider baseline or discuss whether the proposed development could impact on groundwater quality or resources more generally."
And

"Therefore we strongly recommend that groundwater is considered with a section on 'Hydrology, Geology and Hydrogeology' as part of the EIA or consenting application. Alternatively the Scoping Report could be resubmitted to address the omission of information relating these issues."

The purpose of this technical note is to describe the hydrogeological baseline, and to consider any risks related to changes to the groundwater quality or flow regime resulting from the proposed improvements.

2 Proposed Works

Royal HaskoningDHV were commissioned by North Ayrshire Council to develop coastal flood risk management options which include works on land, works on the foreshore, and works within the coastal waters at Millport Bay. All of the options considered for this development will involve the same onshore and foreshore works, and the impacts on the groundwater environment are the same. Therefore, this note does not consider each option separately.

The proposed improvements include new flood walls and improvement works to existing structures onshore, and shore connected rock armour breakwater and rock armour revetment in the foreshore (see

Figure 4-1). No detailed design is available at the time of writing. Assumptions have been made regarding the design of the final structures, and the as-built construction of existing structures, and are described as such.

3 Site Location and Site Description

Millport is located at the southern end of the island Great Cumbrae, within a bay approximately 1.4km in width as shown in **Figure 4-1**, below. Millport town is largely built within a narrow coastal strip, with properties generally located to the landward side of the coastal road (B896).

The western part of the study area comprises predominantly rocky foreshore known as Bessy's Port, but also includes Millport Pier and a small harbour. The central part of the study area comprises a sandy beach, known as Newtown Bay. Further east there is another area of rocky foreshore known as Long Point, and the eastern end of the study area is a sandy embayment known as Kames Bay. The approximate national grid reference for the centre of the site is NS 16509 54986.

4 Baseline environment

Geology

Publicly available geological mapping (BGS, 2018) is presented in **Figure 4-2** and **Figure 4-3** below. Some made ground is expected along roadsides and the waterfront. Superficial deposits overlie sedimentary rock strata of Carboniferous age with igneous intrusions of Carboniferous and Palaeogene age. A north-south trending fault is present at the eastern end of Kames Bay, where the headland is formed by outcropping rock strata of Devonian age. Other significant rock outcrops at the site include Bessy's Port, Long Point and the island group known as "The Eileans".

The British Geological Survey Geology of Britain viewer (BGS, 2018) holds no borehole records in the vicinity of Millport. The anticipated stratigraphy at the site in order of superposition is summarised in **Error! Reference source not found.** below:

Table 4-1 Summary of published geology

Age	Name	Description
Pleistocene and Holocene (Quaternary)	Glacial Till	Moraines of till with outwash sand and gravel deposits.
	Raised Marine Deposits	Sand and gravel.
	Marine Beach Deposits	Sand and gravel.
Palaeogene	Mull Dyke-swarm	Microgabbro.
Carboniferous	Dinantian Dykes	Microgabbro.
	Millport Cornstones Member	Grey sandstone and red-brown silty mudstone with pedogenic limestone.
	Ballagan Formation	Grey mudstones and siltstones, with nodules and beds of ferroan dolomite (cementstones), the beds generally less than 0.3m thick. Gypsum and, to a much lesser extent, anhydrite and pseudomorphs after halite occur.
	West Bay Cornstone Member	Sandstone and nodular limestone (cornstone).
Devonian	Kelly Burn Sandstone Formation	Mainly red, cross-bedded, pebbly sandstone with subordinate conglomerate beds.

Glacial till is present inland of Millport and thus it may be present between the marine beach deposits and the rockhead. The ground investigation undertaken by Royal HaskoningDHV in 2017 confirmed the ground conditions with the study area generally comprise Made Ground overlying marine deposits overlying bedrock (Royal HaskoningDHV, 2017).

Hydrology

There is a small watercourse (Mill Burn) which flows into the West Bay area of Millport from the north (via Mid Kirkton and Nether Kirkton). It appears to be culverted through the town.

There is another small watercourse which flows from the north and emerges onto Kames Bay from a culvert. An Admiralty chart shows dated 1846 (Hydrographic Office of the Admiralty, 1852) shows the watercourse running in a north south direction and discharging into “Kaimes Bay”. There is a “Mill” adjacent to the watercourse approximately 100 m to the north of high water at the bay. This suggests that the watercourse is a heavily modified natural feature, rather than just a surface water drain from the built-up area of Kames Bay.

Hydrogeology

It is assumed that groundwater flow in the vicinity of the town of Millport is likely to be dominated by flow from the centre of the island radially towards the coast. More locally, the flow is likely to be modified by the presence of dykes and faults, and also structures such as quay walls. Groundwater levels, particularly close to the coast, are likely to be tidally influenced.

A number of wells are recorded between 50 m and 100 m inland of the high-water mark within the town of Millport:

- two are recorded adjacent to what is now known as College Street approximately 80 m and 100m north of Glasgow Street,
- four are recorded at the very rear of the gardens of properties on Stuart Street and Guildford Street, immediately next to what is now known as Howard Street; and
- four are recorded in the gardens of properties on Glasgow Street.

This suggests that the Millport Cornstone Member, and possibly the Ballagan Formation, have some degree of conductivity although it is not known whether this is predominantly primary (i.e. intergranular) or secondary (i.e. via fracture flow). It also suggests that the groundwater close to the shore is relatively fresh

Kames Bay Site of Special Scientific Interest (SSSI)

The most sensitive receptor within the study area with respect to the quality of groundwater is the Kames Bay Site of Special Scientific Interest (SSSI). Whilst the flora and fauna of Kames Bay are not understood to be unique or threatened, it is considered to be the classic Scottish site for the study of inter-tidal marine biology, having contributed more to the understanding of marine biology than any other stretch of beach in Scotland. This largely results from the proximity of the University Marine Biological Station (now the Millport Field Studies Council centre) established in 1896. The SSSI Management Statement (SNH, 2000) describes the physical and biological attributes as follows:

“Kames Bay is a small sandy bay with rocky margins. It is the only example on Great Cumbrae of a shore dominated by sand. The bay represents the seaward extension of a geological fault line and the rocks on the western side of the bay are composed of old red sandstone and sandstone conglomerate, whilst the eastern side of the bay is of lower Carboniferous origin.

The dip of the rocks results in the sands being constantly fed with freshwater seepage from the surrounding land. This has important implications on the area's littoral wildlife. The littoral zone is the area of the shore that is occupied by marine organisms which are adapted to, or need, alternating exposure to air and wetting by submersion, splash or spray. The sands are constantly wet and even in summer never experience severe drying, resulting in a high faunal population, including large numbers of the lugworm Arenicola marina and the bivalve Tellina tenuis. This population is always relatively near to the surface and thus readily available to predation by wader species, such as redshank and oystercatcher. Freshwater seepage also produces a variety of salinity profiles in the sand resulting in the occurrence of organisms more typical of estuarine conditions such as the bristle worm Nereis diversicolor and the algae Enteromorpha."

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Figure 4-1 Proposed works (Landside only)

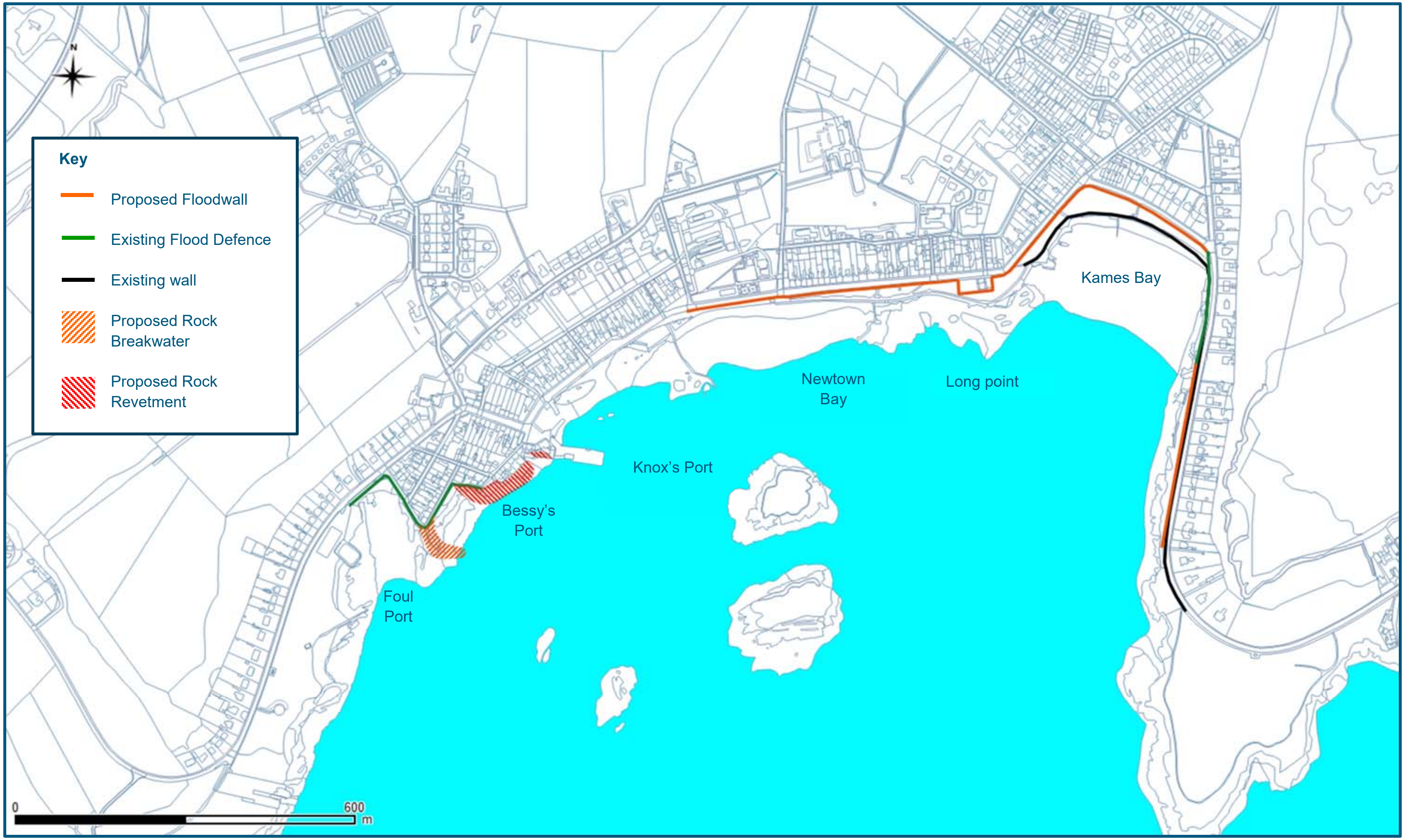

Figure 4-2 Bedrock geology (BGS, 2018)

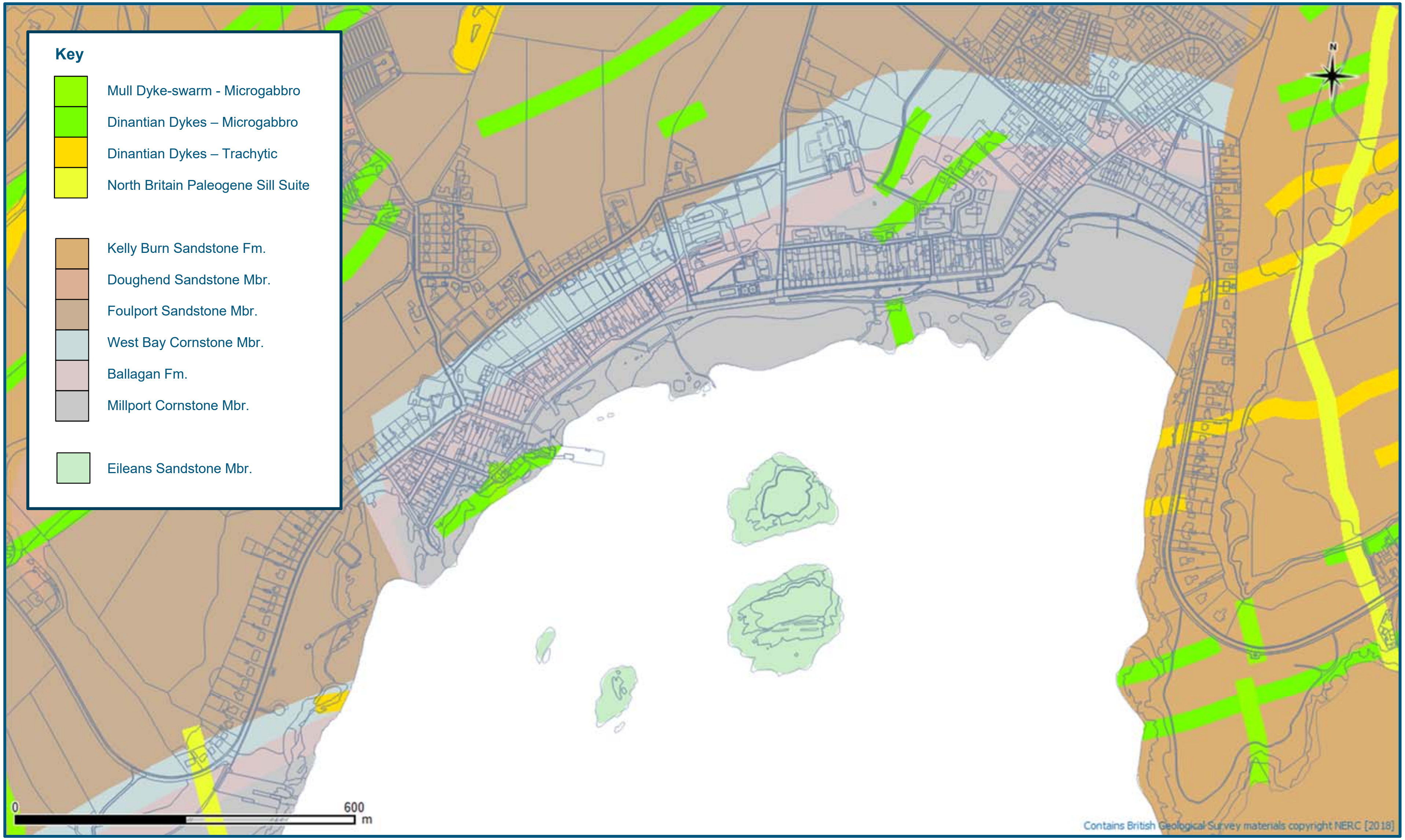

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Figure 4-3 Superficial geology (BGS, 2018)

5 Potential Impact

Impact Mechanisms

The landside elements of the proposed improvements are structurally small and have limited potential to impact of the groundwater flow regime or groundwater quality. The following mechanism have been identified for further consideration:

- Reduction in overtopping of seawater onto landside unmade ground resulting in a reduction of saline water recharging groundwater locally,
- Reduction of discharge of groundwater at the shore due to the placement of low permeability material, and
- Alteration of groundwater flow paths due to the construction of foundations.

Potential Impact on Groundwater Quality and Kames Bay SSSI

Any significant changes to the salinity of groundwater seeping into the sands of Kames Bay have the potential to shift the distribution of the various studied species and thereby disturb the designated features of the SSSI. Work published in 1955 identified the variation of salinity of pore water in the sand as being key to the distribution of the bristle worm *Nereis diversicolor* at Kames Bay (Smith, 1955). Likewise, gross contamination of the groundwater may also impact on the designated features, however no mechanism for gross contamination has been identified.

In a similar way, the flora and fauna of Foul Port, Knox's Port and Newtown Bay can also be considered as receptors for changes to the salinity of groundwater seepage, although these are within the Kames Bay SSSI and are considered of low sensitivity.

The various wells identified in the settlement of Millport are unlikely to now be used for water supply, the island now being supported by a mains water network. It is therefore unlikely that the salinity of water in these wells would be material.

Potential Impact on Groundwater Quantity/Flow Regime

Changes in the groundwater flow regime, particularly those which have the potential to affect the mixing of saline and fresh groundwater, have the potential to impact on the groundwater quality and therefore the most sensitive receptor is considered to be the Kames Bay SSSI, as discussed above.

Reductions to the discharge of groundwater at the shoreline by deep foundations (or other blockages) could also have the effect of raising groundwater levels inland of the structure. As such the foundations of buildings in the residential areas of Millport and the town's sewerage network can be considered as receptors in relation to groundwater flooding.

Consideration of Impacts

The potential for impact from each of the identified impact mechanisms has been considered in turn.

Reduction in overtopping of seawater

The prime purpose of the Millport Flood Protection Scheme is to reduce the frequency and extent of seawater overtopping the current defences. In the centre of Millport, it is expected that overtopping seawater would primarily drain away via the town's sewerage network, and overland flow, back into the bay. In the outlying areas, where the residential gardens are larger and there are large areas of unmade ground, more overtopping is likely to infiltrate the ground and contribute to the salinity of the groundwater.

Adjacent to Kames Bay, the most sensitive receptor, the proposed new flood wall is set back some way from the edge of the beach sands and grassed area, and so there remains the potential for saline recharge to groundwater. During low-frequency coastal flooding events however, the proposed flood wall will act to prevent overtopping (as is its purpose) and there may be some temporary reduction against baseline salinity of groundwater as a result.

Although the residence time for groundwater upgradient of Kames Bay is unknown, the likely high permeability of the shallow subsurface suggests that any pulses of saline water resulting from such low-frequency flood events would be short lived and unlikely to contribute significantly to the prevailing salinity of the pore water on the beach. The extent to which the species of interest at Kames Bay dominate due to ability to survive in intermittently saline conditions is unknown.

The impact of this mechanism on the Kames Bay SSSI and other receptors is considered **unlikely** to be significant.

Reduction of groundwater discharge

As discussed above, the placement of a low permeability barrier upgradient (inland) of the shore, particularly in the Kames Bay areas, could result in a reduction in the discharge of saline groundwater into the pore waters of the sand, and change the location of the freshwater-brackish-saline interfaces at the beach.

Conceptual cross-sections of the Kames Bay are presented in **Figure 5-1**. Groundwater levels are taken from observations of strikes during the intrusive investigations between 10:00 and 15:45 on 19 Jan 2017. Interrogation of tidal data for the Millport Tidal Gauge shows that the low tide on 19 Jan 2017 was recorded at 10:30. The groundwater levels are likely to be tidal and the observed levels are likely to be slightly lower than the mean. The tidal range recorded on 19 Jan 2017 was 2.36 m. The Mean Spring Range (MSR) and Mean Neap Range (MNR) for the Millport tidal gauge are 2.95 m and 1.77 m, respectively. Therefore, the 19 Jan 2017 was roughly midway through the spring-neap cycle.

I can be seen from **Figure 5-1** that the dominant control on the discharge of groundwater is likely to be the existing sea wall. It should be noted that the foundations of the existing sea wall may be significantly deeper than those presented in the figure. It is understood that the maximum depth of the proposed flood wall is 1 m below ground level (bgl). Given that it will be immediately adjacent to the road (and associated low permeability sub-base) and given the depth of the existing sea wall foundations, it is unlikely that the presence of the foundations of the proposed flood wall would act to constrain groundwater flow towards Kames Bay.

The impact of this mechanism on the Kames Bay SSSI is considered **unlikely** to be significant.

The relative levels of the proposed new flood wall and the tidal levels are consistent along the length of the flood wall. There are no groundwater observations in other likely discharge areas (e.g. Foul Port) which to make a similar assessment, however given the lack of sensitivity of the porewater in sands other than at the Kames Bay SSSI, it is considered that the impact of this mechanism on other receptors is considered **unlikely** to be significant.

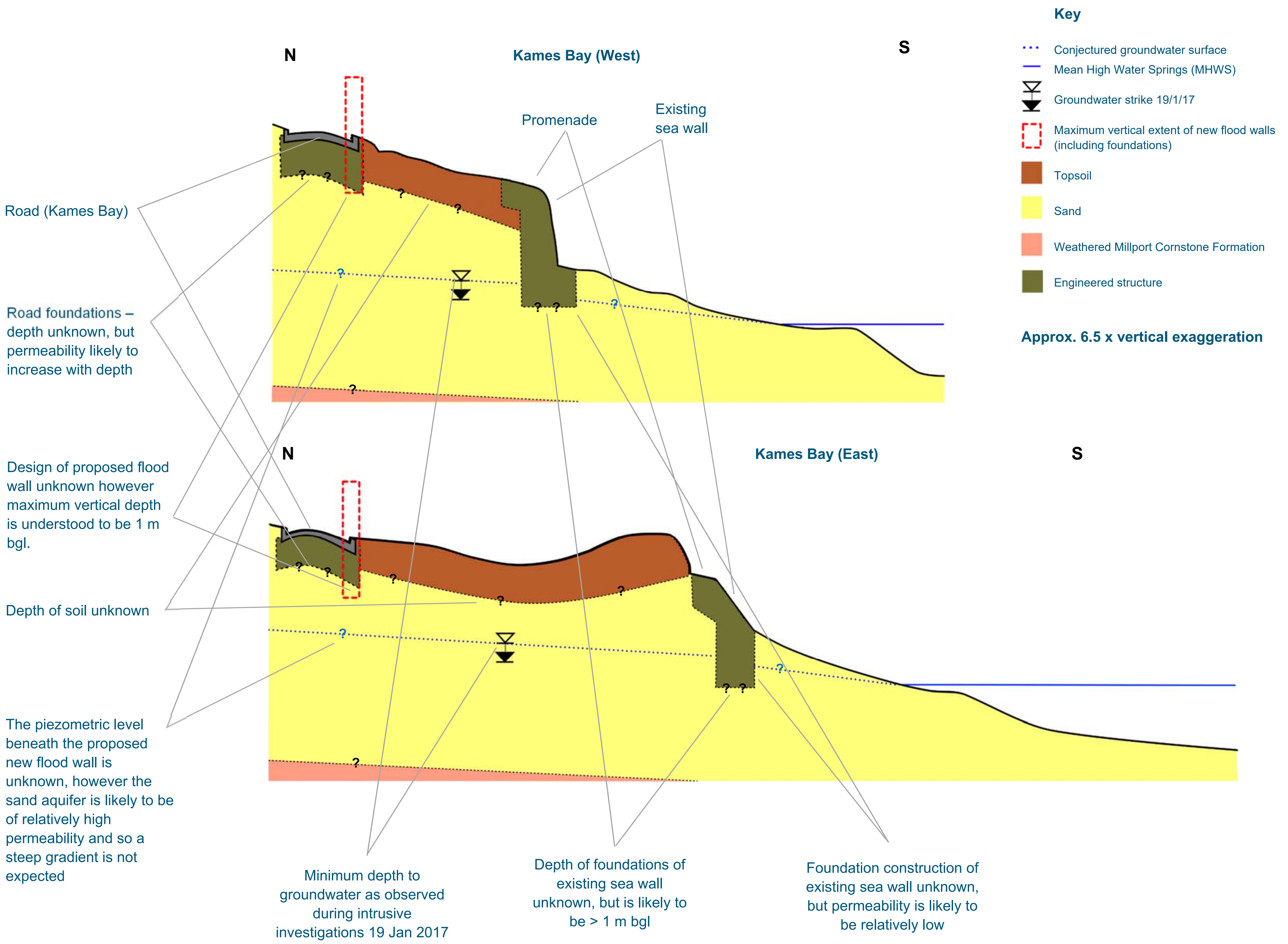
Alteration of flow paths

Associated with the reduction in discharge, the placement of a low permeability barrier across can act to raise the groundwater levels immediately upgradient of the barrier. The construction of a new flood wall in the Newtown Bay and Kames Bay areas could increase the potential for issues related to high groundwater (flooding and inundation of sewerage network). As discussed above, the observations of groundwater strikes in the Kames Bay area suggests that the proposed new flood wall is unlikely to constrain groundwater flow.

Groundwater strikes were recorded in seven trial pits along the Newtown Bay frontage. Only two recorded groundwater at less than 2 m bgl, and none at less than 1 m bgl. It is anticipated that the level of shallow groundwater within this area of Millport is controlled by seepage along the foreshore to Newtown Bay. The area is one of historic development and all the trial pits prove greater than 1 m of Made Ground. It is considered unlikely that the addition of an additional set of foundations would constrain groundwater flow.

The impact of this mechanism on the residential areas of Millport is considered **unlikely** to be significant, especially in the context of the improvements to the management of coastal flooding.

Figure 5-1: Conceptual Cross Sections Kames Bay



6 Summary

Three mechanisms by which the landside elements of the proposed Millport Flood Defence Scheme could potentially impact the groundwater flow regime have been considered in detail:

- Reduction in overtopping of seawater onto landside unmade ground resulting in a reduction of saline water recharging groundwater locally,
- Reduction of discharge of groundwater at the shore due to the placement of low permeability material, and
- Alteration of groundwater flow paths due to the construction of foundations.

The key receptor for changes to the groundwater regime has been identified as Kames Bay SSSI. The proposed flood wall is designed to reduce the frequency of overtopping events, and so periodically may act to limit the influx of saline recharge to the groundwater. However, if this does occur, the affect would be short-lived and unlikely to significantly change the position of the fresh-brackish-saline interfaces within the SSSI.

Using measurements of groundwater strikes observed during the intrusive investigation in January 2017, it is concluded that it is likely that the existing sea wall at Kames Bay is likely to be the dominant control on the discharge of groundwater flow into sands of Kames Bay. The addition of a flood wall with relatively shallow (< 1m) foundations is unlikely to result in constraint to fresh groundwater inflow. The proposed flood wall would be unlikely to significantly change the position of the fresh-brackish-saline interfaces within the SSSI.

The sensitivity of the flora and fauna of other areas of groundwater discharge is much lower than that at the SSSI, and any slight changes in these areas is not considered to be significant.

The potential for the foundations of the proposed new flood wall to cause groundwater levels to rise in the vicinity of Newtown Bay has also been considered. Observations of groundwater strikes during the intrusive investigation in January 2017 suggest that shallow (< 1m) foundations are unlikely to result in constraint of groundwater movement and the risk of problems related to elevated groundwater is not considered to be significant.

7 References

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