Grangemouth Flood Protection Scheme

Habitats Regulations Appraisal

August 2025

Falkirk Council

Grangemouth Flood Protection Scheme

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Contents

1. Introduction

1.1 Project Background

Jacobs has been commissioned by Falkirk Council to undertake an environmental assessment, including a Habitats Regulations Appraisal (HRA), for the Grangemouth Flood Protection Scheme (FPS) (hereafter referred to as 'the Scheme'). A separate Environmental Impact Assessment Report (EIA Report) (Jacobs, 2024) has been conducted for the Scheme.

The flood risk management process in Scotland is driven by the Flood Risk Management (Scotland) Act 2009 (referred to as 'the FRM Act') and the legislative framework outlined within. It established a framework for the assessment and management of flood risks, aiming at the reduction of the adverse consequences of flooding on human health, the environment, cultural heritage and economic activity. The Scheme is being promoted by Falkirk Council as a flood protection scheme pursuant to Section 60 and Schedule 2 of the FRM Act to address flood risk predominately in Grangemouth and the surrounding areas, which include Wholeflats, Glensburgh, Langlees, Carron, Carronshore and Camelon (Stirling Road).

The FRM Act requires the production of two sets of complementary flood risk management plans: Local Flood Risk Management Strategies (led by Scottish Environment Protection Agency (SEPA)) and Local Flood Risk Management Plans (produced by Lead Local Authorities). The Grangemouth area falls within the Forth Estuary Local Plan District and has been identified in the Forth Estuary Flood Risk Management Strategy (SEPA, 2015) as a Potentially Vulnerable Area (PVA) with respect to flooding. This strategy identified the Scheme as the highest priority flood protection scheme of 42 identified across Scotland. It estimated that the Scheme would benefit 1,261 residential properties and 99 non-residential properties at risk of flooding and avoid damages of approximately £6 billion (SEPA, 2015). More recent analysis has identified that the Scheme will protect 2,760 residential properties, 6,025 people, 23km of roads and 1,200 non-residential properties including a refinery, petrochemical plant, a major port and associated nationally important infrastructure (Falkirk Council and Jacobs, 2023a) and avoid £2.4 billion of flood related damages.

The Local Flood Risk Management Plan for the Forth Estuary Local Plan District was first published in June 2016 (The City of Edinburgh Council, 2016). This includes details on the Scheme and lists the following objectives:

- Reduce risk to people in Bonnybridge, Denny, Carron and Grangemouth from river and coastal flooding.
- Reduce economic damages to residential and non-residential properties in Grangemouth caused by river flooding and coastal flooding.
- Reduce economic damages to residential and non-residential properties in Falkirk caused by flooding from the River Carron.
- Reduce economic damages to residential and non-residential properties in Carron and Carronshore caused by flooding from the River Carron and coastal flooding.

The Local Flood Risk Management Plan for the Forth Estuary Local Plan District was updated in 2023 (Falkirk Council, 2023) and the Grangemouth area falls within PVA 02/10/10 (Falkirk and Grangemouth). For this PVA, a number of target areas have been identified, with the following outlining the Scheme as the key action to manage flood risk in the area:

- Carron and Carronshore (target area 211).
- Falkirk (target area 228).
- Grangemouth West (target area 232).
- Larbert and Stenhousemuir (target area 243).
- Polmont, Redding and Westquarter (target area 308).

- The Grangemouth area further extends into PVA 02/10/11 (Bo'ness) and includes Grangemouth East (target area 262), which also references the Scheme as a key action for managing flood risk.

For each target area, further information about the development of the Scheme (including a description, funding and coordination details) are described in the Local Flood Risk Management Plan. The main features deemed as being at risk of flooding from flood events include:

- residential and non-residential properties;
- Falkirk Council infrastructure including buildings, roads, bridges and public spaces;
- utility infrastructure;
- commercial port;
- nationally important infrastructure in the refinery and petrochemical plant; and
- environmentally sensitive sites.

The Scheme will provide protection against coastal, fluvial, seepage (groundwater) and secondary (overland flows trapped behind defences) flood sources and will consist of flood defence walls and embankments, flood gates and demountable barriers, drainage including pumping stations, lock gates (port entrance) and control structures to provide a 1 in 200-year standard level of protection as stated in the Flood Risk Management Strategy (SEPA, 2015). Further information on the Scheme objectives is provided in Section 6.2 (Scheme Objectives) and Section 7.2 (Policy and Legislation).

It is anticipated that the Scheme maybe consented in 2026. Subject to obtaining the relevant permissions and funding being secured, the detailed design will then commence, followed by the construction phase. The Scheme will be constructed in phases over an approximate 10-year period, which is expected to commence in 2028 and continue until 2038. Further construction details are provided in Section 2.4 Construction.

The Scheme is not directly connected with, or essential for, the management of any European or Ramsar site.

1.2 The HRA Process

1.2.1 Introduction

The EU Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora (hereafter referred to as the Habitats Directive) was adopted in 1992 (as amended). The primary aim of the Habitats Directive is to promote the maintenance of biodiversity by requiring Member States to take measures to maintain or restore natural habitats and wild species of European interest listed in the Annexes to the Directive at a favourable conservation status. It also introduces robust protection for those habitats and species of European importance.

The Habitats Directive includes, under Article 3, provision for the designation of Special Areas of Conservation (SACs) for habitats listed on Annex I and for species listed on Annex II. SACs make up the European site network of nature protection areas within the EU, together with Special Protection Areas (SPAs) which are classified under Article 4 of the Birds Directive (Directive 2009/147/EC on the conservation of wild birds (codified version of Directive 79/409/EEC)). The Habitats Directive provides protection for SPAs and SACs from degradation and damaging activities through a hierarchical system of assessment.

Whilst not a European site designation, wetland sites designated under the Convention on Wetlands of International Importance, named as Ramsar sites, are also relevant as they are afforded the same level of protection as European sites under domestic policy, and are treated in the same way as the European site[1] network. Scottish Government policy states that *'Where Ramsar interests coincide with Natura qualifying interests protected under an SPA or an SAC, as the case may be, the interests are thereby given the same level*

[1] As of 01 January 2021, upon the UK's exit from the EU, Natura 2000 sites in Scotland are now referred to as European sites (NatureScot 2023b).

of (legal) protection as Natura sites' (Scottish Government, 2019). Most Ramsar sites in Scotland are also designated as either SPAs or SACs (NatureScot, 2023a), although not always sharing the same qualifying species.

In Scotland, the Habitats Directive is translated into specific legal obligations by the Conservation (Natural Habitats, &c.) Regulations 1994 (as amended). This piece of legislation is hereafter referred to as the Habitats Regulations. The Habitats Regulations require that an Appropriate Assessment (AA) be undertaken by a Competent Authority where any plan or project not directly connected with or necessary to the management of the European/Ramsar site (i.e. a SAC or SPA, or candidate or potential SAC/SPA, or a Ramsar site), is likely to have a significant effect either individually or in combination with other plans or projects. The Habitat Regulations remain in place post 31 December 2020 with only minor changes introduced by the Conservation (Natural Habitats, &c.) (EU Exit) (Scotland) (Amendment) Regulations 2019.

HRA is the process, which includes an AA, whereby a Competent Authority comes to a conclusion as to whether there is no adverse effect on site integrity (AESI) from a plan or project. HRA refers to the process that includes the Competent Authority's conclusions with respect to the AA test concerning site integrity, and the AA must be undertaken '*in view of the site's conservation objectives*'. With respect to this HRA, the Competent Authority will be Falkirk Council.

The application of the precautionary principle is implicit in the Habitats Directive, which requires that the conservation objectives of European sites should prevail where there is uncertainty (European Commission, 2001). Where scientific information is insufficient, inconclusive, or uncertain, the precautionary principle is applied.

The HRA process establishes whether the proposal:

- is directly connected with or necessary for site management for nature conservation;
- is likely to have a significant effect on the site; and
- will not adversely affect the site's integrity.

If the assessment cannot ascertain that the proposal would not adversely affect site integrity and yet the Competent Authority still wish to consent the proposal, a consideration of alternative solutions is required. If no alternative solutions are available, a proposal may be approved for Imperative Reasons of Overriding Public Interest as indicated by Article 6(4) of the Habitats Directive. Compensatory measures '*should be considered only when the application of other safeguards, such as mitigation measures, is not sufficient*' (European Commission, 2007).

The four stages of the HRA process are as follows:

- Stage 1: Screening.
- Stage 2: Appropriate Assessment.
- Stage 3: Assessment of alternative solutions.
- Stage 4: Assessment where no alternative solutions exist and where adverse impacts remain (Imperative Reasons of Overriding Public Interest (IROPI)).

It should be noted that not all stages may be necessary in the HRA process. If the screening stage determines that a plan or project is unlikely to have significant effects on a European/Ramsar site, subsequent stages are not required.

1.2.2 Stage 1: Screening

Screening identifies the potential effects on a European/Ramsar site from a project or plan and considers whether these effects are likely to be significant.

The screening is a test of the 'likelihood' of effects occurring rather than a 'certainty' of effects occurring. In accordance with the Waddenzee Judgement [ECJ case C-127/02], a likely significant effect is one that cannot be ruled out on the basis of objective information. This is underpinned by the precautionary principle which is enshrined in law in the Habitats Directive, and the test of something as being '*beyond reasonable scientific doubt*', as presented in the Waddenzee Judgement. Paragraph 49 of the same judgement adds '*…where a plan or project… is likely to undermine the site's conservation objectives, it must be considered likely to have a significant effect on that site. The assessment of that risk must be made in the light inter alia of the characteristics and specific environmental conditions of the site concerned by such a plan or project*'.

The People over Wind and Sweetman ruling [ECJ case C-323/17] rules out from consideration at the screening stage any measures embedded in a plan or project designed to avoid or mitigate potentially harmful impacts on the European site. The court ruled that '*…it is not appropriate, at the screening stage, to take account of the measures intended to avoid or reduce the harmful effects of the plan or project on that site*'. The ruling requires competent authorities to, at the HRA screening stage, distinguish clearly between mitigation measures specifically designed to avoid or reduce harmful impacts on the European site, and those which are not related to the integrity of the European site. Should there be a need for measures to be specifically designed to avoid or reduce impacts on the European site, the HRA should proceed to Stage 2.

1.2.3 Stage 2: Appropriate Assessment (AA)

If the Stage 1 Screening process determines that the project or plan (either alone or in combination) is associated with impacts which are 'likely to have a significant effect' upon a European/Ramsar site, the HRA proceeds to Stage 2.

An AA considers the effect of the project or plan, either alone or in combination with other projects or plans, on the integrity of the European/Ramsar site, with respect to the site's structure and function, and its conservation objectives. Under the provisions of Article 6(3) of the Habitats Directive, the objective is to ascertain whether the plan or project will have an adverse effect on the integrity of the site, alone or in combination.

Site integrity is defined as '*the coherence of the site's ecological structure and function, across its whole area, or the habitats, complex of habitats and/or populations of species for which the site is or will be classified*' (European Commission, 2000a). The decision as to whether a site is not adversely affected focuses on and is limited to the conservation objectives for the site (European Commission, 2000a; 2018).

In carrying out an AA, mitigation measures, aimed at minimising or avoiding the negative effect of a plan or project during its operation or after its completion, may be considered as an integral part of the plan or project (European Commission, 2000a; 2018). The Competent Authority has to be certain that the mitigation proposed would remove/avoid the negative effects of the plan or project. It must be clear, therefore, what the mitigation measures are, how they would reduce or avoid the effects, and the details of how and by whom they would be implemented/managed and the timescale involved. In addition, the mitigation measures would require monitoring and enforcement, and procedures to rectify effects where measures have not been successful.

1.2.4 Stage 3: Alternative Solutions

Stage 3 is required when an AESI cannot be ruled out. It examines alternative ways of achieving the objectives of the project or plan, that may avoid an AESI on the European/Ramsar site. Guidance (European Commission, 2007) indicates that all alternatives have to be analysed. This could involve alternative locations, different scales or designs of development, or alternative processes.

1.2.5 Stage 4: Assessment Where no Alternative Solutions Exist and Where Adverse Impacts Remain (Imperative Reasons of Overriding Public Interest (IROPI)).

Where no alternative solutions exist and where adverse effects remain as a result of the project or plan, an assessment is undertaken to ascertain whether there are imperative reasons of overriding public interest

(IROPI) and determine whether a project or plan should proceed. Where it is determined that there are IROPI it would be necessary to design, implement, manage and monitor compensation measures *'to offset the negative impact of a project and to provide compensation corresponding precisely to the negative effects…'* (European Commission, 2007).

1.2.6 Guidance

In undertaking this HRA the following guidance was referred to:

- Assessing Connectivity with Special Protection Areas (SPAs) (Scottish Natural Heritage[2] (SNH), 2016a);
- Assessment of plans and projects significantly affecting Natura 2000 sites: Methodological guidance on the provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC (European Commission, 2001);
- Communication from the Commission on the Precautionary Principle (European Commission, 2000b);
- Guidance document on Article 6(4) of the 'Habitats Directive' 92/43/EEC. Clarification of the Concepts of: Alternative Solutions, Imperative Reasons of Overriding Public Interest, Compensatory Measures, Overall Coherence, Opinion of the Commission (European Commission, 2007);
- Guidelines on the Implementation of the Birds and Habitats Directives in Estuaries and Coastal Zones, with particular attention to port development and dredging (European Commission, 2011);
- Habitats Regulations Appraisal of Plans: Guidance for Plan-making Bodies in Scotland, Version 3.0 January 2015 (David Tyldesley and Associates, 2015);
- Habitats Regulations Appraisal (HRA) on the Firth of Forth: A Guide for developers and regulators (SNH, 2016b);
- Managing Natura 2000 Sites: The provisions of Article 6 of the 'Habitats' Directive 92/43/EEC (European Commission, 2000a);
- Managing Natura 2000 sites: The provisions of Article 6 of the 'Habitats' Directive 92/43/EEC (European Commission, 2018); and
- NatureScot's web guidance: Habitats Regulations Appraisal (HRA) (NatureScot, undated).

1.2.7 Structure of this Report

This HRA fulfils the requirements of Article 6(3) and Article 6(4) of the Habitats Directive and covers all four stages of the HRA process:

- Stage 1 (Screening): The outcome of the assessment and identification of Likely Significant Effects (LSEs) from the Scheme (Section 3: Stage 1 (Screening));
- Stage 2 (Appropriate Assessment): The assessment of the Scheme's implications for European/international sites in view of the sites' conservation objectives to ascertain if the integrity of the sites would not be adversely affected (Section 4: Stage 2 (Appropriate Assessment)).
- Stage 3 (Alternative Solutions): Details of possible alternative solutions to the Scheme and whether they would deliver the overall objectives of the Scheme and/or be less damaging to the integrity of the site(s) affected (Section 6: Stage 3 (Alternative Solutions));
- Stage 4 (Imperative Reasons of Overriding Public Interest (IROPI)): Information to demonstrate that there are imperative reasons of overriding public interest that justify the consent of the Scheme despite the adverse effects it could cause (Section 7: Stage 4 (Imperative Reasons of Overriding Public Interest (IROPI))).

Details of designated sites discussed within this report are presented in Appendix A (European and Ramsar Site Details), and detailed survey data which has been used to inform the assessment is presented in Appendix B (Ornithological Information).

[2] SNH changed their name to NatureScot as of 24th August 2020

An assessment of the Scheme in combination with other plans and projects is provided in Section 3.4 (In-Combination Effects) and Appendix E (In-Combination Assessment).

Following confirmation of no alternative solutions and that there are imperative reasons of overriding public interest, compensatory measures to ensure that the overall coherence of the European site network is protected have been developed and are described in Section 8 (Compensation).

Thirty-four figures have been prepared to support this HRA and these are referenced where appropriate throughout this document. The figures have been grouped below with a brief description of their contents:

- Figure 1: Scheme overview
- Figures 2 to 7: Flood defence designs within each Flood Cell
- Figure 8: Typical cross sections of flood defences
- Figure 9: European sites that could be impacted by the Scheme
- Figure 10: Bird survey areas
- Figures 11 and 12: GI works and associated noise monitoring locations
- Figures 13 to 18: Construction noise contours
- Figures 19 to 21: Habitat information
- Figures 22 to 32: Wintering bird survey data
- Figure 33: In-combination projects and plans
- Figure 34: Compensation site details

2. The Scheme

2.1 Introduction

The Grangemouth area has an extensive history of flood events that have occurred since the 1920s. Details of the more notable flood events are provided in Table 2.1. Whilst none of the more recent flood events have reached the level of the major flood event in 1959, the frequency of events has notably increased since the beginning of the twenty first century.

Table 2.1: History of key known flooding events around Grangemouth

Source of flooding	Date	Description of flooding/event
Snow melt and rainfall	2022	Flooding around Dorrator Bridge and Falkirk Golf Course and various other locations along the River Carron. Grange Burn very high and surface water flooding to Zetland Park.
High intensity thunderstorm	2020	Flooding from the Polmont/Westquarter Burns at Cadgers Brae/Klondye and Beancross resulted in properties being inundated. Disruption to roads and railway network, flooding from the River Avon on Wholeflats Road. Highest ever flow recorded on the River Avon at Polmonthill. Surface water flooding in parts of Grangemouth.
River Carron	2020	Widespread flooding of the River Carron catchment, closure of Stirling Road and properties at Threepwood were flooded.
High intensity thunderstorm	2019	Flooding from the Polmont Burn at Klondyke resulted in the Premier Inn and Brewers Fayre being flooded. Disruption to roads and railway network.
Grange Burn	2018	Predicted tide level of 3.93m Above Ordnance Datum (AOD) caused water levels in the Grange Burn to rise significantly and come within centimetres of bank top and bridge structure.
Tidal Surge	2014	Tidal surge coupled with high tide was predicted to affect the Forth Estuary, very high water levels on the Grange Burn.
Grange Burn	2013	Tidal surge coupled with high tide was predicted to affect the Forth Estuary, very high water level in the Grange Burn and some flooding within the Port and Petrochemical complex.
River Carron	2011	Blocked culvert at the Chapel Burn led to flooding of properties in the vicinity.
Westquarter Burn/ Polmont Burn	2011	Significant flooding across the Falkirk Grangemouth area, flooding at Beancross/ Klondyke and Reddoch Road.
River Carron	2006	Widespread flooding throughout the Falkirk area with residential and business properties affected. Larbert bus depot impacted and Anchor Burn footbridge was washed away. Closure of A883 at Checkbar, five properties flooded at Threepwood (River Carron). Carronside Place in Dunipace evacuated amid fear of flooding. Flooding of the Tor Burn affected Bogend Road.
River Carron/Chapel Burn	2002	22 properties flooded on Alloa Road in Stenhousemuir.
Forth Estuary	1959	Major flood event in the Grangemouth area. Grangemouth Docks flooded with highest tide recorded at 4.47m.
Grange Burn	1927	Abbots Road, Kerse Road and Jackson Avenue flooded.
Grange Burn	1926	Sudden rise of 1.67m of water level in Grange Burn, flooding was recorded on Jackson Avenue at Grangemouth, rising approximately 0.9m above the ground level.

Following the 1959 major flood event, a 2,040m long flood relief channel was constructed to alleviate flood risk: this commences at an overflow weir on the Grange Burn and terminates at the downstream confluence with the River Avon. Additionally, embankments were raised along the Grange Burn. Other existing flood

protection measures within the area include earth embankments, gabion baskets, rock revetments, rock groynes, masonry/concrete walls, sheet piles and rubble causeways.

A detailed flood risk mapping study undertaken by Jacobs was developed initially in 2011-2012 and has been updated, with the most recent version completed in 2023 (Jacobs, 2023). This assessed a combination of flood events from fluvial sources and tidal sources, surge events and wave overtopping. The study revealed the potential for extensive and deep inundation during a 1 in 200-year event (0.5% annual probability of occurrence).

Flood modelling was used to estimate the likelihood and extent of flooding to inform the area requiring protection by the Scheme. The Scheme has been designed to manage the risk from fluvial and tidal flooding in six discrete Flood Cells, as shown in Figure 1. The cells were delineated based on the geographical location and extents of the catchment area.

2.2 Existing Conditions

2.2.1 Site Location

The Scheme is located within the Falkirk Council area and is centred around the town of Grangemouth, which is approximately 5km northeast of the town of Falkirk and 30km west of the city of Edinburgh. Some sections of the Scheme extend into the boundaries of smaller settlements including Glensburgh, Langlees, Carron, Carronshore and Larbert. Three main water courses flow through Grangemouth and the surrounding area into the Forth Estuary (River Carron, River Avon and Grange Burn), which is designated as an SPA and Ramsar site due to its importance to nature conservation.

Grangemouth has a population of approximately 15,991 (Scottish Government, 2021), and most residential properties are located around the centre of the town, bounded by the M9 to the south, with the refinery/ petrochemical plant, the Port of Grangemouth and other commercial buildings predominating to the east, north and west. Grangemouth has a long history of industrial activity; approximately half of the Grangemouth area is dominated by the Port of Grangemouth and a petrochemical plant facility.

2.2.2 The Port of Grangemouth

The Port of Grangemouth is Scotland's largest container port and refrigerated container terminal. It handles 9 million tonnes of cargo each year through specialist container, liquid and general cargo terminals and it facilitates the flow of more than £6 billion worth of goods annually (Forth Ports Group, 2023). Multiple vessel movements in and out of the port are recorded daily; it is estimated that 1,000 vessel movements occur at the port annually. To support and supply the vessel movements, a significant number of vehicle movements occur within the port and the port has multiple vehicle entrances which have good connections with the national road and motorway network. The port also has a railway line linked to main east and west coast lines and there is a weekly rail link with the Port of Tilbury in London, enabling movement of goods between the two ports (Forth Ports Group, 2023).

The Port of Grangemouth operates 24 hours a day, 365 days a year and plays a significant role in importing and exporting goods in Scotland and to the Grangemouth petrochemical plant. The port is continuously lit, with vertical light columns spread throughout the site for security and to enable 24-hour working.

2.2.3 Petrochemical Plant

The town's economy is heavily reliant on the petrochemical industry, with almost 2000 people employed directly by the INEOS, INEOS FPS and Petroineos businesses. Grangemouth is home to Scotland's only crude oil refinery, which provides the country with most of its fuel needs and is of strategic importance to Scotland's energy supply. Forty percent of the UK's oil and gas from the North Sea oil fields is transported via the Forties pipeline, and is processed at the Grangemouth petrochemical plant, while substantial quantities of other petrochemical products are exported to industries across the UK and beyond (INEOS, 2023).

The Grangemouth petrochemical site generates approximately 4% of Scotland's Gross Domestic Product (GDP) and was the first place in the UK to import US shale gas-derived ethane. The site produces over 1.3 million tonnes of petrochemicals annually and around 9 million litres of fuel which is supplied to petrol stations and airports (including Scotland's major airports: Glasgow, Edinburgh, and Prestwick) (INEOS, 2023). Therefore, the ongoing functioning of the facilities at Grangemouth has economic relevance to other areas beyond the town and it is a site of national economic importance. Within the petrochemical site, there are multiple flares which are regularly used. The frequency and duration of flaring is highly dependent on the flow of oil and gas from the North Sea pipeline and the production at the site. The petrochemical plant operates 24 hours a day and 365 days a year. Periodically, parts of the site have 'shutdowns' for essential maintenance and upgrade work. The shutdowns are typically for a few weeks and take years of planning.

In September 2024, Petroineos '*announced its intention to cease refinery operations at Grangemouth and transition to a finished fuels import terminal and distribution hub during the second quarter of 2025, subject to consultation with employees*' (INEOS, 2024). It was stated that the INEOS and INEOS FPS businesses will continue as normal. The Scottish and UK Governments have committed to investing in the Grangemouth site to secure a long-term industrial future and facilitate the transition to a green energy hub. Both governments have committed to review the Project Willow feasibility study, which has identified nine key investment areas which are viable low-carbon alternatives for the refinery site (Scottish Government, 2025).

2.3 Description of the Scheme

The Scheme comprises a series of flood protection measures along the three main watercourses (River Carron, River Avon, Grange Burn), targeted sections of their tributaries (Westquarter Burn, Polmont Burn and Millhall Burn), and the Firth of Forth estuary. The outline design includes a series of new flood walls and embankments which when combined have an approximate total length of 28km. Other measures comprise relining the flood relief channel, coastal revetments, a new flow control structure (on the Grange Burn) and modification/replacements to bridges. The Scheme will provide protection for more than 3,000 properties, the petrochemical plant, port area and nationally important infrastructure up to a 1 in 200-year standard of protection.

The Scheme has been divided into six Flood Cells, with each Flood Cell then sub-divided into distinct Working Areas (Figure 1). The Working Areas are based on form of construction, geographic divisions, source of flooding and sensible breaks within the Flood Cells. It is anticipated that the contractor will develop their own programme and sequence of construction based on the Flood Cells or Working Areas. More information on the construction activities associated with the Scheme, including details on construction methodology, phasing and advance works, can be found below in Section 2.4 and in Appendix C: Construction Methodology Report.

2.3.1 Scheme Layout

As noted previously, the outline Scheme design includes a combination of flood protection measures such as fluvial and coastal flood walls, earth embankments, a new flood control structure and relining of the existing flood relief channel. To accommodate these measures, the Scheme also includes flood gates, ramps, footpaths, ground raising, bridge raising, restoration of the river channel/banks, three replacement bridges, other bridge modifications, and landscaping. The existing A9 (Beancross) underpass will be blocked off and infilled. A new at-grade, traffic signal-controlled crossing is to be provided on the A9 west of this underpass.

The height above ground level of flood defences will vary along their length, averaging a height of 1.0 – 1.5m, with a maximum height of 3.9m. The specific flood defence heights at each section may be subject to refinement at the detailed design stage.

Appendix C: Construction Methodology Report provides more details on the design and construction for the whole Scheme and the outline Scheme design for each Flood Cell is detailed on Figures 2 to 7.

The following Working Areas fall within or are immediately adjacent to the Firth of Forth SPA and Ramsar site:

- all Working Areas in Flood Cell 3 (Working Areas 3-1 to 3-5);

- Working Area 4-9 in Flood Cell 4;
- Working Area 5-4 in Flood Cell 5; and
- all Working Areas in Flood Cell 6 (Working Areas 6-1 to 6-4).

Working Areas 2-1 and 2-2 in Flood Cell 2 are located on the other side of the River Carron from the Firth of Forth SPA and Ramsar site boundary.

Those areas in proximity to the SPA and Ramsar site include a combination of the following flood management measures:

- Coastal flood walls: concrete walls with sheet piles and rock armour coastal revetments (Flood Cells 3 and 6) to attenuate wave action. Flood walls will be constructed where space is restricted along the estuary and embankments are not possible.
- Earth embankments: granular filled embankments with an impermeable core (possibly clay, concrete or bentonite core). Embankments in Flood Cells 3 and 6 will also have coastal revetments to attenuate wave action.
- Flood gates: used to allow access through the flood defences (Working Areas 2-2, 5-4 and 6-2).
- Replacement lock gates to the entry lock to the Port of Grangemouth.
- Culverts: new and/or extensions to existing culvert will be required at Working Area 6-1.

Due to the very soft estuarine deposits, it will be necessary to carry out ground improvement or piling under the footprint of the proposed defence structures so that the ground is capable of supporting the structure.

Details of the measures proposed for Flood Cells 2, 3, 4 (Working Area 4-9 only), 5 (Working Area 5-4 only) and 6, divided by Working Area, are provided in Table 2.2.

Information on the construction process for flood walls, embankments and coastal revetments can be found in Appendix C: Construction Methodology Report and typical cross sections the defence types of are shown on Figure 8.

Table 2.2: Summary of the proposed flood protection measures in Flood Cells 2, 3, 4 (Working Area 4-9 only), 5 (Working Area 5-4 only) and 6.

Flood Cell No.	Working Area	Location	Length of Flood Defences (m)	Type of Flood Defences
2	2-1	Forth and Clyde Canal Lock	662	Earth embankment and bare sheet pile wall
	2-2	Jarvie Plant/Rossco Properties	840	Bare sheet pile wall
3	3-1	Mouth of the River Carron	922	Bare sheet pile wall and coastal revetments.
	3-2	West Coast of the Port	962	Bare sheet pile wall and coastal revetments.
	3-3	West Gate to the Port	1169	Bare sheet pile wall and coastal revetments.
	3-4	East Gate to the Port	992	Sheet pile wall, plain concrete wall and formed concrete wall. Coastal revetments will be installed along the defences south from the port's east gates.
	3-5	Mouth of the Grange Burn	682	Bare sheet pile wall
4	4-9	Mouth of Grange Burn	1142	Sheet pile wall, seepage only

Flood Cell No.	Working Area	Location	Length of Flood Defences (m)	Type of Flood Defences
5	5-4	Mouth of the River Avon	438	Sheet pile wall with coastal revetments: revetments will be installed along the northern boundary of INEOS FPS compound.
6	6-1 & 6-2	West of River Avon (Beach Road & Mouth of River Avon)	2166	Sheet Pile Wall, Bored Pile Wall with revetment
	6-3 & 6 -4	East of River Avon (Chemical Works at River Avon & Chemical Works)	1420	Sheet Pile Wall & Embankment

2.4 Construction

2.4.1 Introduction

The likely construction methodology for the Scheme has been developed during outline design and has been used as the basis on which the construction impacts for the HRA have been assessed. The construction information within this section primarily focusses on the Working Areas in the vicinity of the Firth of Forth SPA and Ramsar site, however, the Construction Methodology Report in Appendix C provides details for all Working Areas across the Scheme. The extent of the likely construction Working Areas for Flood Cells 2, 3, 4 (Working Area 4-9 only), 5 (Working Area 5-4 only) and 6 are shown on Figures 3 to 7.

Construction methods will be developed further during detailed design, in liaison with stakeholders such as statutory consultees, landowners/operators, utilities companies and Falkirk Council. Whilst the final construction methods will be determined by the construction contractor, the design team have identified the worst-case feasible methods based on ground investigation information, design specifications, environmental constraints, terrain, and access requirements. Developments in technology between the completion of this assessment and construction of each phase of the Scheme may allow for quieter, more efficient methods to be implemented. The design and implementation of temporary works, which includes construction access, will be detailed in the contractor's method statements and submitted to Falkirk Council for acceptance. Any required consents for temporary works will be obtained by the contractor. Any potential impacts to the SPA due to changes to the detailed design at construction stage will be assessed and discussed with NatureScot as appropriate.

An Outline Construction Environmental Management Plan (CEMP) will be prepared and made available prior to confirmation of the Scheme. A more detailed CEMP will be developed by the appointed contractor(s) in accordance with relevant standards and guidance. The CEMP will include the findings of the HRA and its conclusions and will set out any necessary mitigation. An Environmental Clerk of Works will be appointed, as well as an Ecological Clerk of Works (ECoW), who together will oversee construction works.

2.4.2 Site Compounds

At the outline design stage, the number and locations of the proposed site compounds are still to be confirmed, however, it is estimated that 12 site compounds will be required across all Flood Cells to facilitate construction works. It should be noted that due to the phasing of construction, not all site compounds are expected to be active at the same time. There are two site compound locations that are currently adjacent to the estuary edge - compound 3-A and 3-B in Flood Cell 3 by the Port of Grangemouth lock gates. Figures 13 and 14 identify that the anticipated noise generated during the set up and operation of the compound sites will attenuate to acceptable levels before reaching the intertidal area (further information is provided in Section 4.5: Noise Assessment). Whilst the compound locations could move within the port, it is unlikely that they would be any

closer to the estuary due to the existing infrastructure and limited suitable space. No compounds would be situated within the petrochemical plant due to health and safety considerations.

The main site compounds would comprise offices, welfare facilities, parking and space for storage of materials and equipment. Additional smaller site compounds provide localised welfare facilities and storage to service the more remote work sections. Activity within the site compounds would take place within normal working hours, 08:00-18:00. Some additional lighting would be required, particularly during the winter months. This lighting would be directed into the compound area to reduce light spill into the surrounding areas.

It is anticipated that Flood Cells 2 and 6 would have one compound each and Floo Cell 3 would have two site compounds. Working Areas 4-9 and 5-4 would not have a site compound. In Flood Cell 2, the potential compound is in an industrial area at the south east end of the Port of Grangemouth and the potential site compounds in Flood Cell 3 are located adjacent to the direct defences within the port, with existing roads providing access to the Working Areas in both Flood Cells. In Flood Cell 6, the proposed site compound is located on an area of grassland south of the waste water treatment works. The potential locations identified for site compounds and main access routes to these are shown on Figures 2 to 7. As the availability of land for site compounds may change over the construction period, it is possible that their location may be revisited by the appointed contractor.

2.4.3 Enabling Works

In advance of the main works contract, enabling works (such as utility diversions, preparation of working areas, etc.) may be carried out to reduce the risk of delay to the main works, to provide greater certainty of cost, and to reallocate activities which are more suited to specialist contractors.

Grangemouth contains numerous buried and overhead utilities, and the construction of the flood defences may be hindered due to the works being too close to or conflicting with these. To minimise this risk, each utility provider would be consulted to determine which utilities can be diverted and which should be protected to enable the planning and implementation of the utility diversions to be completed in advance of the construction works.

Tree felling would be required to enable access to the banks of watercourses and facilitate construction of the flood defences. Trees would either be felled before main works commence or by making the main works contractor responsible for the felling. Falkirk Council are unlikely to determine their preferred approach to tree felling until the Scheme is confirmed and they commence the procurement of contractors.

The exact timing of enabling work is not set in the programme. Once the Scheme is confirmed, enabling works could take place any time after this, subject to funding and obtaining the necessary consents.

2.4.4 Main Construction Works

The main Scheme construction works would include works associated with establishing compound sites and working areas, piling, earthworks, concrete construction, demolishing existing structures and buildings, movement of materials, wall cladding, surfacing and landscaping.

There are many constraints associated with construction works near watercourses, namely the proximity of buildings, roads and other infrastructure on or adjacent to the watercourse banks. Therefore, construction of some lengths of flood defences would likely be required from the ‘wet side’ of the defence (i.e. from the side closest to the watercourse), and include in-water working where accessing works from the ‘dry side’ (i.e. from the side furthest from the watercourse) is not considered feasible, or where there are access or health and safety issues.

2.4.4.1 In-Water Works

There will be a need for in-water working in all Flood Cells. All in in-water Working Areas are shown on Figures 2 to 6 and the locations of relevance to this HRA are:

- Flood Cell 2: Working Area 2-2 (Jarvie Plant).
- Flood Cell 3: Working Areas 3-1 (mouth of the River Carron), 3-3 (west gate to port) and 3-4 (east gate to port).
- Flood Cell 4: Working Area 4-9 (mouth of Grange Burn).
- Flood Cell 5: Working Area 5-3 (Grangemouth Road).
- Flood Cell 6: Working Areas 6-1 (Beach Road) and 6-2 (Petroineos mouth of River Avon).

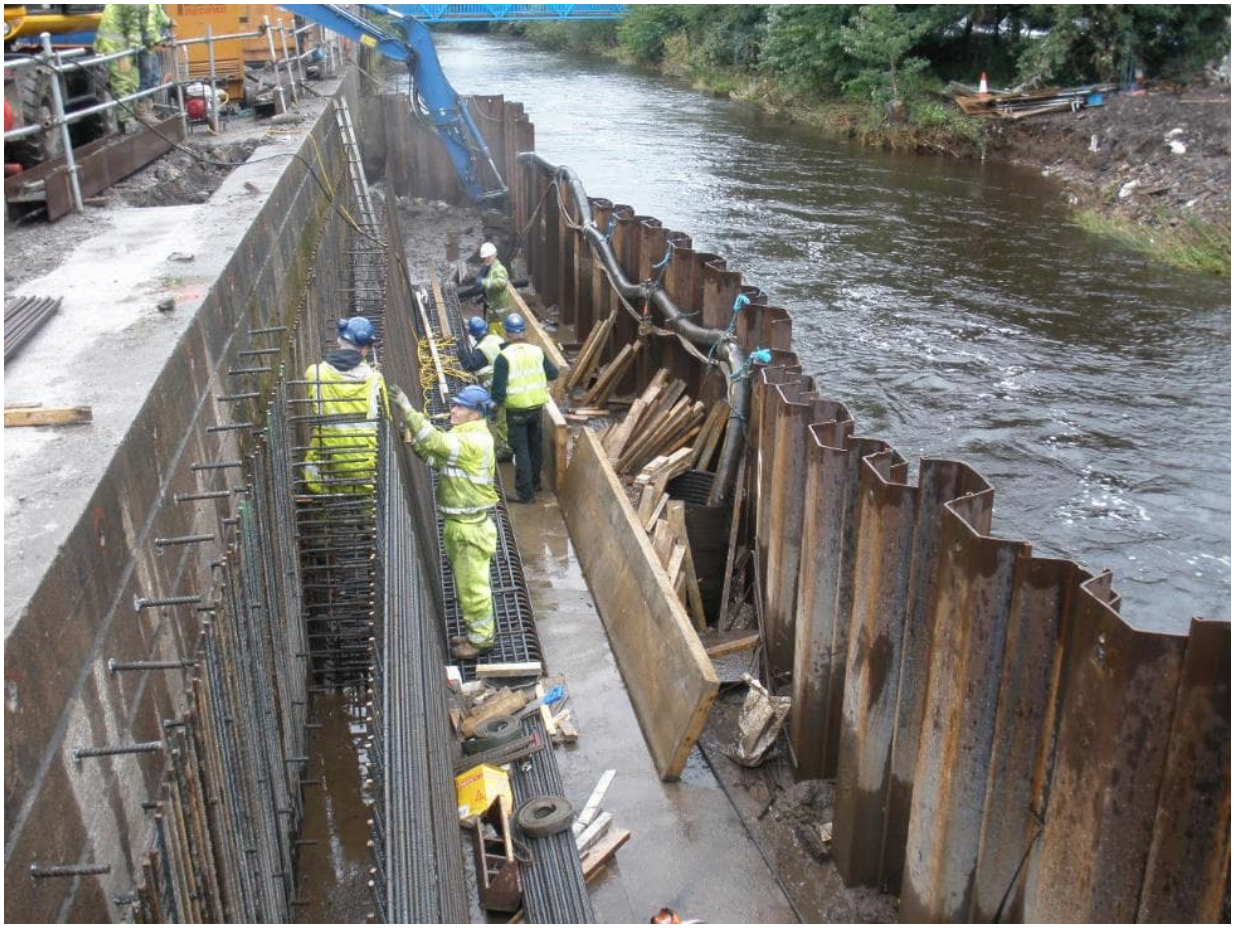
Where possible, works would be completed from the banks of watercourses and the estuary within the areas identified for in-water working. In some instances, this would mean plant and materials located adjacent to the water and only minimal in-water working for specific activities (such as an excavator bucket removing substrate at the toe of existing defences): it is anticipated that this will be feasible for some sections of Working Areas 2-2, 3-1, 3-3 and 4-9.

In-water working would also be facilitated by temporary features. In some locations, temporary raised working platforms would be constructed up to 9m wide to accommodate the required construction plant. It is likely that raised working platforms would be used for some works within the River Carron (Working Areas 2-2 and 3-1), Grange Burn (Working Area 4-9), and within the River Avon (Working Area 5-3).

The platforms would likely be created from clean crushed rock (approximately 75-150mm in size) placed on a separation geotextile and surrounded with sand/stone-filled bulk bags to hold the granular fill in place. This would create a dry working area for personnel and machinery to construct the flood protection measures, and for plant to move between work sections on the wet side of the defences. The platform would be high enough to ensure that work can progress without regular interruption from changing water levels, (e.g. above mean high water level) and the specific heights at each location will be confirmed during the detailed design stage. An example of a raised working platform is provided in Photograph 2.1.

Photograph 2.1: Example of a raised working platform at White Cart Water FPS, Glasgow

Other options to facilitate in-water working include the use of cofferdams, where a temporary dam would be constructed, typically using sheet piles, around the area of works to exclude water. An example of a cofferdam is provided in Photograph 2.. It is likely that a cofferdam would be used in Working Areas 3-3 to construct the flood wall across the western lock. A much smaller limpet cofferdam, which would attach to side of the existing port wall, is also likely to be used in Working Area 3-4 to install the new flood/lock gates. As piling is required, installation of a cofferdam is typically noisier than creating a working platform. However, due to the soft sediment along the estuary, it is anticipated that an air hammer would not be required to install the sheet piles, and therefore the noise generated when installing cofferdams would be in line with typical construction plant movement. Where the underlying ground is permeable, the differential water pressure across the cofferdam may cause groundwater to seep up through the bottom of the dry area, which would require the water to be pumped out to keep the working area in the cofferdam dry. It is likely that the other works in Working Areas 3-3 and 3-4 can be constructed from the bank or from a barge.



Photograph 2.2: Example of a cofferdam at White Cart Water FPS, Glasgow

Access to the in-water working areas in Flood Cells 1 to 5 is anticipated to be achieved via a combination of ramps (existing and new ones), existing bridges and temporary construction bridges. In Flood Cell 6, access will be determined by the contractor, however, this is likely to include a haul road constructed along the edge of the Firth of Forth Estuary, with the footprint of the haul road forming part of the foundation for the rock revetment. Further details of in-water working methods can be found in Appendix C (Construction Methodology Report).

2.4.4.2 Coastal Works

Due to the extremely soft ground along the estuary frontage, improvement works to the existing ground are required to increase the strength (bearing capacity) of the ground to facilitate construction of flood defences within Working Areas 6-1 and 6-2. The flood defences will consist of bored piles into the improved ground, with a concrete wall situated on top of the piles and rock armour revetment flush with the wall on the estuary side. The bored pile is likely to be concrete and extend no more than 4m below the existing ground level. The bored pile will have a concrete capping beam and a reinforced concrete wall stem or pre-cast concrete wall stem.

Ground improvement works will be undertaken before the installation of piles and rock revetment and the improved ground will form part of the temporary haul road along the estuary frontage. The ground improvement process will require an additive (such as lime, cement or pulverised fly ash (PFA)) to be mixed into the ground to a depth of up to 4m below existing ground level (this depth is determined by the required depth of the bored pile at each location). The additive will be mixed with water to create a thick paste which will be pumped to a rotavator head and mixed into the existing ground using an excavator. This will quickly bind within the existing substrate and harden – no leaching of the additive will occur into the surrounding area.

Works within this coastal area will be dictated by the tides. Soil mixing will only be conducted when the tide has receded past the working area and will halt in sufficient time before the area is submerged by the rising tide each day. Once the soil mixed ground has cured sufficiently, the excavator with the mixing head and pump will track over the soil improved ground and begin mixing the next area of ground. This process will continue along the estuary frontage until all the necessary ground has been mixed.

Geotechnical sampling and testing will be carried out to ensure the improved ground achieves the specified design parameters.

Further information on the soil mixing methods is provided in Appendix C (Construction Methodology Report).

2.4.4.3 'Dry Side' Construction

The remainder of the works would be constructed from the dry/protected side of the defences and would likely include earthworks and excavation works up to 3m in depth. It is anticipated that the works would result in some disturbance to local traffic, as temporary diversions and road closures may be required. The duration of closures would be dependent on the form of construction and constraints set by other stakeholders (e.g. owners, operators and Falkirk Council).

Several measures have been proposed to minimise the effects of construction traffic. Primarily, preferred routes have been identified to and from site compounds and individual construction sites. It has also been recommended that all construction traffic use the trunk road network or A-class roads and only deviate where necessary to reach individual sites. Several other traffic management measures have been proposed, including:

- provision of alternative routes for diverted traffic and appropriate signage;
- regulated site working hours in order to avoid heavy volumes of movement during peak hours in the morning and evening when general traffic levels will be higher than normal;
- installation of additional (temporary) warning and speed control signs;
- provision of a wheel wash facility and road sweeper to minimise any mud and debris on the surrounding public road network and prevent the introduction of non-native/invasive plant material to the site;
- formation of a construction liaison committee to ensure the smooth management of the project – public interface;
- introduction of temporary parking restrictions and alternative parking arrangements where on and off-street parking is restricted as a result of the Scheme;
- temporary closure of public rights of way and provision of suitable alternative routes; and
- stationing of a "Stop-Go" banksman to facilitate communication between drivers.

It is also anticipated that a Traffic Management Plan will be developed at the detailed design stage to further minimise the effects of construction traffic associated with the Scheme.

2.4.4.4 Temporary Flood and Erosion Protection

The sequence of construction may temporarily lower the standard of flood protection within the individual Flood Cells where flood defences have yet to be constructed. Temporary changes to the standard of flood protection is inevitable as all defences cannot be constructed simultaneously. During construction, the appointed contractor would be required to provide temporary flood protection measures within each Flood Cell until construction of the permanent defences is complete to maintain at least the current standard of protection across the Scheme. Temporary flood protection measures could be in the form of sandbags, bags filled with granular fill, temporary flood barriers or pumps to remove water.

Some temporary erosion protection of the riverbanks may be required, should the working areas increase the risk of scour. Such protection will take the form of geotextile and rip rap/armour stone and will only be implemented following a period of monitoring and discussion with the relevant stakeholders.

2.4.4.5 Reinstatement Works

As part of the construction phase of the Scheme, nearly all access tracks and Working Areas (including in-water) will be removed in their entirety and habitats will be reinstated. These reinstatement works will fall within the overall construction programme and are assessed as part of the construction phase. The area of soil improved ground to facilitate construction of defences within Working Areas 6-1 and 6-2 cannot be fully reinstated due to the additive mixed into the substrate and therefore this will be included within the permanent works habitat loss calculations.

A habitat management plan will be developed which will include measures to reduce damage and encourage recovery of the habitats affected by construction works, in particular the intertidal areas of the estuary.

2.4.5 Anticipated Construction Programme

The Contractor will be responsible for developing the programme and sequencing of construction works, subject to any constraints imposed by the project team and/or planning/licence conditions. The construction period for the Scheme is estimated to be up to 10 years, with discrete sections being completed in phases within that timeframe. Table 2.3 identifies the approximate duration to construct flood defences within the Flood Cell Working Areas of relevance to the HRA. Construction works are anticipated to be carried out from Monday to Friday, over a period of 50 working weeks each year.

Table 2.3: Approximate duration of construction works within the Flood Cell Working Areas of relevance to the HRA.

Cell No	Working Area	Approximate Duration (Months)
2	All Working Areas (2-1 and 2-2)	15
3	All Working Areas (3-1 to 3-5)	42
4	4-8 and 4-9	12
5	5-3 (downstream of Grangemouth Road) and 5-4	21
6	East extents (6-1 and 6-2)	21
	West extents (6-3 and 6-4)	18

The key dates for the anticipated construction programme are outlined below, assuming the hearing for the Scheme is concluded by 2026.

- Enabling works: 2028.
- Main construction phase: late 2028 – 2038 (Scheme operational by 2038).
- Defects correction period: minimum two years post construction works (landscape maintenance period is to be confirmed in due course).

The dates above are subject to change and will be periodically reviewed.

2.4.5.1 Sequencing of Construction Works

The Scheme is a complex project, involving construction, logistics, watercourse management, traffic management and public interface, and is spread over a large spatial area. Due to its scale and spatial extent, it is likely that construction works will be divided into at least four construction phases, with each phase potentially involving more than one construction contract. At this stage the construction phasing cannot be confirmed, but it is likely that construction work will take place in a range of Flood Cells within each construction phase as detailed in Table 2.4.

Table 2.4: Possible split of Flood Cells into construction phases

Phase Number	Flood Cell
1 (Mainly residential properties)	1, 2, 4 (part), and 5 (part)

Phase Number	Flood Cell
2 (Port lock gates)	3
3 (Port flood defences)	3
4 (Industrial areas)	4 (part), 5 (part) and 6

The sequencing and timing of these works is not definitively known, and construction contracts could overlap. The sequencing of construction works is likely to mean that only two construction phases can be undertaken at the same time. Construction works within Flood Cells 3 and 6 predominantly fall within or directly adjacent to the Firth of Forth SPA and Ramsar site. Therefore, it will be stipulated that any works undertaken adjacent to the SPA within Flood Cells 3 and 6 will be undertaken independently of each other, with a gap of at least one winter (October to March) in between, to reduce disturbance to the qualifying species of the Firth of Forth SPA and Ramsar site. The lock gates are located within the busy Port of Grangemouth. This area is outwith the Firth of Forth SPA and bird numbers recorded during surveys were low. Therefore, works at the lock gates within Flood Cell 3 may overlap with other works in Flood Cell 3 or 6. The following diagram provides an indicative illustration of how the phasing of contracts may occur, with each colour indicating a separate construction contract (Diagram 2.1).

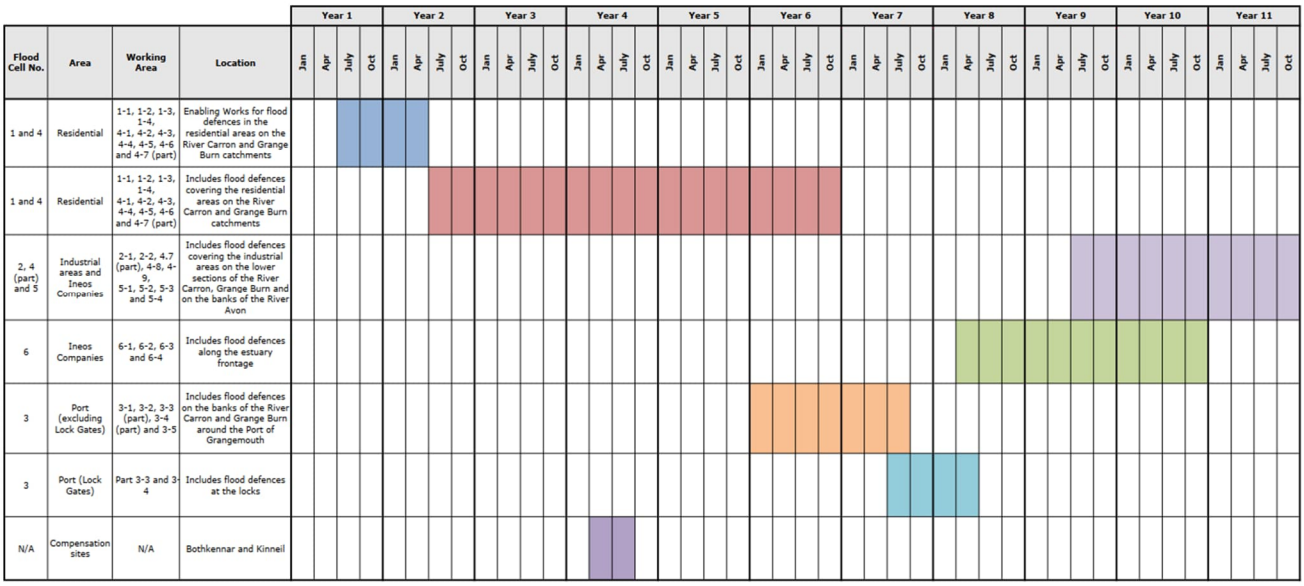


Diagram 2.1: Indicative phasing of construction contracts.

While it will be for the contractor to establish a construction programme, some contract constraints on the sequencing of works shall be incorporated to manage environmental impacts during the construction period. These will include:

- restrictions to minimise disturbance to sensitive protected species or designated nature conservation sites;
- restrictions on the total length of haul roads in place at any one time;
- restriction on the length of the Working Area which can be closed to the public at any one time;
- restrictions on in-channel works, especially those that would prevent fish passage; and
- restriction on work which disturbs the riverbed during salmon spawning season (depending on the limitations enforced in the CAR licence).

2.4.6 Likely Plant, Materials and Waste

At this outline design stage, there is limited detail on the machinery and materials required and waste likely to be generated by the Scheme. However, Table 2.5 and 2.6 set out an indicative list of the likely equipment and materials required for the whole Scheme during construction.

Table 2.5: Indicative list of likely plant to construct the Scheme

Indicative List of Construction Plant			
360 degree tracked/wheeled excavators	Dumpers/tipper lorries	Mobile cranes	Tracked/Non-tracked piling equipment
Vibrating roller compactors	Vibrating plate compactors	Concrete cutting equipment	Concrete pumps and skips and vibrating pokers
Burning and steel cutting and welding equipment	Drilling and coring equipment	Mobile pumps	Mobile settlement tanks
Mobile generators	Mobile compressors	Mobile heaters	Tarmac planers and pavers

Table 2.6: Indicative list of likely material to construct the Scheme

Indicative List of Materials			
Cohesive, low permeability fill for embankments	Granular fill (sands, gravels, rock)	Additives (cement, lime or pulverized fly ash (PVA))	Rock armour stone
Topsoil	Steel sheet piles	Precast concrete piles	Mass and reinforced concrete
Seeds, trees and plants	Geotextiles	Timber fencing	Metal fencing
Bitumen macadam	Plastic pipework and ductwork	Metal pipework	Concrete pipework
Mechanical/electrical pumps	Stonework, brickwork, and reconstituted stone products	Precast concrete products	Glass products
Metal and plastic fixings and fixtures	Hydrocarbon-based cellular products	Organic-based coatings and sealants	Hydrocarbon-based paints, coatings, and sealants
Lighting, wiring and fixtures	Fuel oils	Steel flood gates and lock gates	

The estimated quantities of materials required for the construction of selected structures included within the Scheme design are listed in Table 2.7.

Table 2.7: Indicative quantities of materials to construct the Scheme (materials for fluvial walls and re-lining of a flood relief channel are not included)

Asset	Material	Quantity	Units
Embankments	Primary aggregate	155,600	m^3
	Steel	1,230	m^3
Tidal walls	Concrete	1,765	m^3
	Steel	247	t
	Steel	570	m^3
Bank protection	Erosion matting	68,520	m^2
Rock armour	Primary aggregate	227,870	t
	Damp-proof coarse membrane	58,430	m^2
Headwalls	Concrete	100	m^3
	Steel	14	t
Drainage pipe	Plastics	975	m^3
	Concrete	2,525	m^3
	Iron	3	m^3
Lock Gates	Steel	80	t
Flood Gates	Steel	15	t
Landscaping (soil and grass seed)	Soil/Clay	24,000	m^3
Path	Asphalt	1,870	m^2
Permanent access points	Primary aggregate	20	m^3
Soil mixed ground	Additives (cement, lime or PFA)	49,000	m^3

The number of staff likely to be directly associated with construction of the cells adjacent to the Firth of Forth estuary is unknown, but it would comprise operatives, managers, administration staff, supervisors and an environmental clerk of works, and is estimated to be a minimum of 27 and maximum of 110 personnel during peak periods of construction.

At this stage of design, limited information is known about the waste that could be generated by the project. The detailed design will consider resource efficiency and waste minimisation in order to identify the materials that can be reduced, reused or recycled. However, it is anticipated that main waste is likely to comprise inert materials, potentially contaminated soils and made ground.

All such waste would require disposal in accordance with the Waste Regulations, with waste that meets the landfill Waste Acceptance Criteria taken into a local material recycling facility/landfill site. Any special waste designated under the Special Waste Regulations 1996 must be disposed in accordance with the relevant SEPA guidance. The volume of special waste would depend on the extent of ground contamination, which would only be fully known at the time of construction.

The contractor would be required to prepare management plans and method statements for carrying out the construction works. For example, the contractor would be required to prepare a Site Waste Management Plan, which would contain details of how different waste materials would be handled, in accordance with the waste hierarchy and regulatory requirements. Also, as part of their method statements, the contractor would be required to propose appropriate methods for works at or near watercourses for managing sedimentation risk.

2.5 Operation and Maintenance

Operation effects of the Scheme will be negligible due the fixed nature of the flood defences.

The Scheme has been designed to have minimal operation and maintenance requirements during the life of the project (anticipated to be over 100 years). Once constructed, the Scheme will only require intervention to operate and maintain the flood protection measures by Falkirk Council and others. These will be set out in an operation and maintenance manual, which will be developed at a later stage, but it is anticipated that annual inspections of the flood defences and coastal revetments will be required. Topping up of coastal revetments

may be required approximately every 15-20 years post-construction. Although the duration and periodicity of these topping up events are unknown due to their very nature, due consideration and restrictions to ensure the conservation objectives of the SPA will not be compromised will be undertaken during these maintenance events. Due to the improved ground stability achieved by soil mixing in Working Areas 6-1 and 6-2, it is expected that these areas will require less maintenance works in the future, than would otherwise have been required.

The key operation and maintenance tasks for flood defences adjacent to the Firth of Forth estuary will be:

- closure of the flood gates during periods of predicted flood risk, and re-opening afterwards;
- erection of demountable flood defences in the port along the lock;
- regular maintenance checks, such as the walls/embankments for structural defects, operation of flap-valves and identifying any damage from vandalism. Flood gates and seals will be checked on an annual basis and after a significant flood to check for damage or wear and tear;
- closure of port lock gates and railway flood gates;
- maintenance works as required, such as carrying out any pointing, cladding repairs, cleaning, replacing seals, vegetation clearance, removal of debris from bridges; and
- landscape maintenance of the embankments and landscaped areas, as defined during detailed design.

The plant, materials and personnel required for the operation and maintenance works will be minor in comparison with that required for the construction phase. Falkirk Council will be responsible for operating and maintaining the flood defences. At this stage it is estimated that two to five personnel will be directly involved in the operation and maintenance of the flood defences, however this may significantly increase during a flood event. Access to all flood defences for maintenance has been considered during the design process. Within the Port of Grangemouth, access will primarily be taken from existing roads. Within Flood Cell 6 along the estuary, a permanent access track will be constructed directly behind the flood defences and outwith the petrochemical plant fenceline.

Where possible, maintenance works should be timed to occur in the summer months when most qualifying species of the Firth of Forth SPA and Ramsar site are either absent or present in lower numbers. However, it is acknowledged that occasionally emergency maintenance works may be required during winter months, for example as a result of storm damage. Compensation habitat will be created for the Scheme (Section 8: Compensation), which will be maintained throughout the lifespan of the Scheme and provide alternative habitat for qualifying bird species of the Firth of Forth SPA and Ramsar site during any maintenance works. Therefore, the integrity of the European site network will be maintained.

Defences along the estuary between Grange Burn and the River Avon (Working Areas 6-1 and 6-2) have been designed and constructed to account for climate change. The new lock gates within the Port of Grangemouth have also been constructed to account for climate change. The remaining defences have been designed to allow for future flexibility, in that the flood wall/embankment foundations have been designed so that the defences may in future be increased in height. This measure would mitigate the future impacts of climate change, where flood events are predicted to become more frequent and severe. Any alterations to flood defences to account for climate change, which could affect the Firth of Forth SPA and Ramsar site, will be taken forward as a new Scheme and will be assessed in a separate HRA.

2.6 Decommissioning

It is highly unlikely that the Scheme will be demolished within the foreseeable future, as the Scheme is anticipated to be maintained for over 100 years. Should demolition be required, it is anticipated that any future local authority will ensure that the relevant consents are attained, and environmental procedures are followed in accordance with relevant guidance and environmental protective measures.

3. Stage 1 (Screening)

3.1 Introduction

This section details the Stage 1 Screening of the HRA process, which comprises the following:

- determining whether the project or plan is directly connected with or necessary to the management of a European/Ramsar site;
- identifying the potential for effects on European/Ramsar sites individually or in combination with other plans and projects; and
- assessing the likely significance of any potential effects on European/Ramsar sites.

As stated in Section 1.1 (Project Background), the Scheme is not directly connected with, or essential for, the management of any European or Ramsar site.

3.2 European Sites with Potential Effects from the Scheme

Guidance dictates that all European/Ramsar sites, and their qualifying features, which have the potential to be affected by a plan or project should be considered as part of the HRA process. For the assessment of the Scheme, relevant European and Ramsar sites were identified by looking for potential source-receptor pathways. In addition, NatureScot provided guidance on designated sites to be included within this HRA in their response to the Scoping Report for the Scheme (Jacobs, 2018). The following sites were identified to be considered within the screening process (Figure 9), namely:

- Firth of Forth SPA (NatureScot, 2023c);
- Firth of Forth Ramsar (JNCC, 2008a; NatureScot, 2023d);
- River Teith SAC (NatureScot, 2023e);
- Forth Islands SPA (NatureScot, 2023f);
- Imperial Dock Lock, Leith SPA (NatureScot, 2023g);
- Isle of May SAC (NatureScot, 2023h);
- Outer Firth of Forth and St Andrews Bay Complex SPA (SPA) (NatureScot 2022, NatureScot 2023i);
- Slamannan Plateau SPA (NatureScot, 2023j);
- Loch Leven SPA (NatureScot, 2023k); and
- Loch Leven Ramsar (JNCC, 2008b; NatureScot, 2023l).

Qualifying species, conservation objectives and pressures on feature condition (Scotland's Environment, 2019) are presented in Table 3.1 below, and in Appendix A (European and Ramsar Site Details).

Table 3.1: European and Ramsar sites to be included in Stage 1 Screening for LSEs

Area (ha)	Qualifying Interest	Conservation Objectives	Site Description	Identified Feature Pressures
UK9004411 / 8499 Firth of Forth SPA (NatureScot, 2023c)				
6,317.93	The site qualifies under Article 4.1 of the Directive (79/409/EEC) by regularly supporting populations of European importance of the following Annex 1 species: • bar-tailed godwit (*Limosa lapponica*)*, non-breeding • golden plover (*Pluvialis apricaria*)*, non-breeding • red-throated diver (*Gavia stellata*)*, non-breeding • Sandwich tern (*Thalasseus sandvicensis*)[1], passage • Slavonian grebe (*Podiceps auritus*)*, non-breeding The site qualifies under Article 4.2 of the Directive (79/409/EEC) by regularly supporting populations of European importance of the following migratory species (all non-breeding): • knot (*Calidris canutus*)* • pink-footed goose (*Anser brachyrhynchus*)* • redshank (*Tringa totanus*)* • shelduck (*Tadorna tadorna*)* • turnstone (*Arenaria interpres*)* The site qualifies under Article 4.2 of the Directive (79/409/EEC) by regularly supporting a waterfowl assemblage of national importance. Assemblage qualifying species (all non-breeding): • bar-tailed godwit • common scoter (*Melanitta nigra*) • cormorant (*Phalacrocorax carbo*) • curlew (*Numenius arquata*) • dunlin (*Calidris alpina alpina*) • eider (*Somateria mollissima*) • goldeneye (*Bucephala clangula*)	To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained; and To ensure for the qualifying species that the following are maintained in the long term: • population of the species as a viable component of the site • distribution of the species within site • distribution and extent of habitats supporting the species • structure, function and supporting processes of habitats supporting the species • no significant disturbance of the species	The Firth of Forth SPA is a mosaic of estuarine and coastal habitats spanning the length of the Forth Estuary. The intertidal mudflats, saltmarsh, rocky shores and bays that provide important food sources and shelter for the qualifying, wintering, birds and passage migrants are included within the extensive 6,317.93ha designated site boundary. The Firth of Forth SPA is designated for 27 species; comprising five Annex I species, five individually-cited species (due to the presence of internationally important populations) and an assemblage of 17 waterbird species.	• Game/fisheries management • Recreation/disturbance • Water quality • Climate change • Natural event

Area (ha)	Qualifying Interest	Conservation Objectives	Site Description	Identified Feature Pressures
	• golden plover • great crested grebe (*Podiceps cristatus*) • grey plover (*Pluvialis squatarola*) • knot • lapwing (*Vanellus vanellus*) • long-tailed duck (*Clangula hyemalis*) • mallard (*Anas platyrhynchos*) • oystercatcher (*Haematopus ostralegus*) • pink-footed goose • red-breasted merganser (*Mergus serrator*) • red-throated diver • redshank • ringed plover (*Charadrius hiaticula*) • scaup (*Aythya marila*) • Slavonian grebe • velvet scoter (*Melanitta fusca*) • wigeon (*Mareca penelope*)[2] • turnstone			
UK13017 / 8424 Firth of Forth Ramsar (NatureScot, 2023d)				
6,317.93	The site qualifies under Ramsar criterion 2 by supporting (1993/4 to 1997/98 winter peak means): • red throated Diver (90 individuals, 2% of the GB population) • golden plover (2949 individual, 1% of the GB population) The site qualifies under Ramsar criterion 4 by supporting the following waterbird species at a critical stage in their life cycles: • common scoter • cormorant	The Ramsar Convention's mission is '*the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world*'.	The Ramsar site comprises a complex of estuaries, mudflats, rocky shorelines, beaches and saltmarshes. The site provides habitat for large numbers of wintering waders and wildfowl, many in nationally and internationally important numbers (NatureScot, 2023d). It is estimated that 90% of the world's population of pink-footed geese spend winter on wetland and farmland habitats in the UK (Scottish Wildlife Trust, 2019).	• Game/fisheries management • Recreation/disturbance • Climate change • Water quality

Area (ha)	Qualifying Interest	Conservation Objectives	Site Description	Identified Feature Pressures
	• curlew • dunlin • eider • great crested grebe • grey plover • long-tailed duck • oystercatcher • red-breasted merganser • ringed plover • scaup • velvet scoter The site qualifies under Ramsar criterion 5 by regularly supporting waterbirds in numbers of 20,000 individuals or more. In the five-year period 1992/93 to 1996/97, a winter peak mean of 95,000 individual waterbirds was recorded, comprising 45,000 wildfowl and 50,000 waders. The site qualifies under Ramsar criterion 6 by regularly supporting 1% or more of the individuals in a population of waterbird: Qualifying species/populations with peak counts in spring/autumn: • pink-footed goose • redshank • shelduck • turnstone Qualifying species/populations with peak counts in winter: • bar-tailed godwit • goldeneye • knot • Slavonian grebe Qualifying passage species:			

Area (ha)	Qualifying Interest	Conservation Objectives	Site Description	Identified Feature Pressures
	• Sandwich tern[1]			
UK0030263 / 8367 River Teith SAC (NatureScot, 2023e)				
1,289.33	The site is designated for the following qualifying species: • Atlantic salmon (*Salmo salar*) • brook lamprey (*Lampetra planeri*) • river lamprey (*Lampetra fluviatilis*) • sea lamprey (*Petromyzon marinus*)	To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to achieving favourable conservation status for each of the qualifying features; and To ensure for the qualifying species that the following are maintained in the long term: • population of the species, including range of genetic types for salmon, as a viable component of the site • distribution of the species within site • distribution and extent of habitats supporting the species • structure, function and supporting processes of habitats supporting the species • no significant disturbance of the species	The River Teith is the most significant tributary of the River Forth, flowing eastward through Central Scotland and discharging into the Firth of Forth west of Stirling.	• Forestry operation • Invasive species • Water quality • Water management
UK9004171 / 8500 Forth Islands SPA (NatureScot, 2023f)				
9,797.01	The site qualifies under Article 4.1 of the Directive (79/409/EEC) by regularly supporting populations of European importance of the following Annex 1 species (all breeding): • Arctic tern (*Sterna paradisaea*)* • common tern (*Sterba hirundo*)* • roseate tern (*Sterna dougallii*)* • Sandwich tern* The site qualifies under Article 4.2 of the Directive (79/409/EEC) by regularly supporting populations of	To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained; and To ensure for the qualifying species that the following are maintained in the long term: • population of the species as a viable component of the site • distribution of the species within site • distribution and extent of habitats supporting the species	The Forth Islands SPA includes a number of islands in the Firth of Forth (Figure 8) and is classified on the basis of supporting populations of European importance of eight seabird species as well as an assemblage of over 20,000 seabirds. The nearest island of the SPA (Long Craig island) is located approximately 16km from the Scheme. Roseate, common and Sandwich terns are the only qualifying species of the Forth Islands SPA known to regularly nest on Long Craig island and are present in large numbers (equivalent to 1% or more of the SPA population at classification) (Jacobs Arup, 2009).	• Inter-specific competition • Climate change • Game/fisheries management • Proactive on-site management • Invasive species • Recreation/disturbance

Area (ha)	Qualifying Interest	Conservation Objectives	Site Description	Identified Feature Pressures
	European importance of the following migratory species (all breeding): • gannet (*Morus bassanus*)* • lesser black-backed gull (*Larus fuscus*)* • puffin (*Fratercula arctica*)* • shag (*Phalacrocorax aristotelis*)* The site qualifies under Article 4.2 of the Directive (79/409/EEC) by regularly supporting a seabird assemblage of national importance. Assemblage qualifying species (all breeding): • Arctic tern • cormorant • gannet • guillemot (*Uria aalge*) • herring gull (*Larus argentatus*) • kittiwake (*Rissa tridactyla*) • lesser black-backed gull • puffin • razorbill (*Alca torda*) • roseate tern • Sandwich tern • shag	• structure, function and supporting processes of habitats supporting the species • no significant disturbance of the species		
UK9004451 / 8668 Imperial Dock Lock, Leith SPA (NatureScot, 2023g)				
0.11	The site qualifies under Article 4.1 of the Directive (79/409/EEC) by regularly supporting breeding populations of European importance of the following Annex I species: • common tern, breeding	To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained; and To ensure for the qualifying species that the following are maintained in the long term: • population of the species as a viable component of the site • distribution of the species within site	The Imperial Dock Lock, Leith SPA is a man-made structure at the mouth of the Imperial Dock in the Port of Leith. The SPA supports the largest colony of common tern in the Forth (an average of 558 pairs, 1997-2001).	• Other

Area (ha)	Qualifying Interest	Conservation Objectives	Site Description	Identified Feature Pressures
		• distribution and extent of habitats supporting the species • structure, function and supporting processes of habitats supporting the species • no significant disturbance of the species		
UK0030172 / 8278 Isle of May SAC (NatureScot, 2023h)				
356.64	Annex I habitats present as a qualifying feature, but not a primary reason for selection of this site: • reefs Annex II species that are a primary reason for selection of this site: • grey seal (*Halichoerus grypus*)	To avoid deterioration of the qualifying habitat thus ensuring that the integrity of the site is maintained, and the site makes an appropriate contribution to achieving favourable conservation status for each of the qualifying features; and To ensure for the qualifying habitat that the following are maintained in the long term: • extent of the habitat on site • distribution of the habitat within site • structure and function of the habitat • processes supporting the habitat • distribution of typical species of the habitat • viability of typical species as components of the habitat • no significant disturbance of typical species of the habitat To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to achieving favourable conservation status for each of the qualifying features; and To ensure for the qualifying species that the following are maintained in the long term:	The Isle of May is located at the entrance to the Firth of Forth and supports a breeding colony of grey seals. The site is the largest breeding colony of grey seals on the east coast of Scotland and the fourth-largest breeding colony in the UK, contributing approximately 4.5% of annual UK pup production (JNCC, 2019).	• Invasive species • Water management

Area (ha)	Qualifying Interest	Conservation Objectives	Site Description	Identified Feature Pressures
		• population of the species as a viable component of the site • distribution of the species within site • distribution and extent of habitats supporting the species • structure, function and supporting processes of habitats supporting the species • no significant disturbance of the species		
UK9020316 / 10478 Outer Firth of Forth and St Andrews Bay Complex SPA (NatureScot, 2022 and 2023i)				
272,068.10	The site meets the qualifying requirements under Article 4.1 of the Directive (79/409/EEC) by regularly supporting populations of European importance of the following Annex I species: • Arctic tern, breeding • common tern, breeding • little gull (*Hydrocoloeus minutus*), non-breeding • red-throated diver, non-breeding • Slavonian grebe, non-breeding The site meets the qualifying requirements under Article 4.2 of the Directive (79/409/EEC) by regularly supporting populations of European importance of the following migratory species: • black-headed gull (*Chroicocephalus ridibundus*), non-breeding • common gull, non-breeding • common scoter, non-breeding • eider, non-breeding • gannet, breeding • goldeneye, non-breeding • guillemot, breeding and non-breeding • herring gull, breeding and non-breeding	To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, subject to natural change, thus ensuring that the integrity of the site is maintained in the long-term and it continues to make an appropriate contribution to achieving the aims of the Birds Directive for each of the qualifying species. This contribution will be achieved through delivering the following objectives for each of the site's qualifying features: a) Avoid significant mortality, injury and disturbance of the qualifying features, so that the distribution of the species and ability to use the site are maintained in the long-term; b) To maintain the habitats and food resources of the qualifying features in favourable condition.	The Outer Firth of Forth and St Andrew's Bay Complex comprises an area of 272,068.10ha which stretches from Arbroath to St. Abb's Head and comprises the Firth of Forth, the outer Firth of Tay and St Andrew's Bay. The site extends beyond the 12NM (Nautical Mile) boundary of territorial and offshore waters to encompass feeding, moulting and roosting grounds of 21 qualifying species of breeding and/or wintering seabirds and waterfowl.	n/a[3]

Area (ha)	Qualifying Interest	Conservation Objectives	Site Description	Identified Feature Pressures
	• kittiwake, breeding and non-breeding • long-tailed duck, non-breeding • Manx shearwater (*Puffinus puffinus*), breeding • puffin, breeding • razorbill, non-breeding • red-breasted merganser, non-breeding • shag, breeding and non-breeding • velvet scoter, non-breeding			
UK9004441 / 9184 Slamannan Plateau SPA (NatureScot, 2023j)				
590.91	The site qualifies under Article 4.2 of the Directive (79/409/EEC) by regularly supporting nationally important numbers of the following migratory species: • Taiga bean geese (*Anser fabalis fabalis*)	To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained; and To ensure for the qualifying species that the following are maintained in the long term: • population of the species as a viable component of the site • distribution of the species within site • distribution and extent of habitats supporting the species • structure, function and supporting processes of habitats supporting the species • no significant disturbance of the species	Slamannan Plateau lies east of Cumbernauld, in the headwaters of the River Avon. It consists of two small lochs and their surrounding peatlands and associated areas of rough and improved grassland. The site supports roosting and feeding taiga bean geese during winter. This flock is the only regular wintering flock of bean geese in Scotland and one of only two in the UK, with over 50% of the total UK population in recent years (NatureScot, 2023h).	n/a[3]
UK9004111 / 8530 Loch Leven SPA (NatureScot, 2023k)				
1,611.29	The site qualifies under Article 4.1 of the Directive (79/409/EEC) by regularly supporting populations of European importance of the following Annex I species: • whooper swan (*Cygnus cygnus*), non-breeding The site qualifies under Article 4.2 of the Directive (79/409/EEC) by regularly supporting populations of European importance of the following migratory species:	To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained; and To ensure for the qualifying species that the following are maintained in the long term:	Loch Leven in central Scotland is the largest natural eutrophic lake in Britain. It is a relatively shallow loch, surrounded by farmland, with a diverse aquatic flora and shoreline vegetation (NatureScot, 2020a).	n/a[3]

Area (ha)	Qualifying Interest	Conservation Objectives	Site Description	Identified Feature Pressures
	• pink-footed goose, non-breeding • shoveler The site qualifies under Article 4.2 of the Directive (79/409/EEC) by regularly supporting a waterfowl assemblage of national importance. Assemblage qualifying species (all non-breeding): • cormorant • gadwall (*Anas Strepera*) • goldeneye • pochard (*Aythya farina*) • shoveler (*Anas clypeata*) • teal (*Anas crecca*) • tufted duck (*Aythya fuligula*)	• population of the species as a viable component of the site • distribution of the species within site • distribution and extent of habitats supporting the species • structure, function and supporting processes of habitats supporting the species • no significant disturbance of the species		
UK13033 / 8436 Loch Leven Ramsar (NatureScot, 2023l)				
1,611.29	The site qualifies under Ramsar criterion 1 by containing a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region: • largest naturally eutrophic loch in Britain The site qualifies under Ramsar criterion 2 by supporting vulnerable, endangered, or critically endangered species or threatened ecological communities (1993/4 to 1997/8 winter peak mean): • whooper swan (97 individuals, 2% of the GB population) The site qualifies under Ramsar criterion 5 by regularly supporting 20,000 or more waterbirds (1993/94-1997/98 winter peak mean): • 34,280 waterfowl The site also qualifies under Ramsar Criterion 4 by supporting the following waterbird species at a critical stage in their life cycles: • cormorant (391 individuals, 3% of the GB population)	The Ramsar Convention's mission is '*the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world*'.	The Ramsar site is a particularly good example of a naturally eutrophic loch. It is the largest loch of its kind in Britain, being both large and shallow with only rare stratification. It supports characteristic flora and fauna, including the nationally rare invertebrates *Macroplea appendiculata*, *Thanatophilus dispar* and *Saldula fucicola* (JNCC, 2008a).	n/a[3]

Area (ha)	Qualifying Interest	Conservation Objectives	Site Description	Identified Feature Pressures
	• gadwall (245 individuals, 3% of the GB population) • goldeneye (339 individuals, 2% of the GB population) • teal (2,771 individuals, 2% of the GB population) • pochard (1,095 individuals, 2% of the GB population) • tufted duck (3,636 individuals, 6% of the GB population), and The site further qualifies under Ramsar Criterion 6 by regularly supporting 1% or more of the individuals in a population of waterbirds (1993/1994 to 1997/1998): • pink-footed goose (winter peak mean of 17,163 individuals, 8% the Eastern Greenland/Iceland/UK biogeographic population), and • shoveler (winter peak mean of 509 individuals, 1% of North Western & Central Europe biogeographic population)			

*species also an assemblage qualifier
[1]Formerly *Sterna sandvicensis*
[2]Formerly *Anas penelope*
[3]Site is not included in Scotland's Environment Pressures webpage

3.3 Screening

The construction and operational phases of the Scheme could result in a variety of LSEs which could directly or indirectly affect European/Ramsar sites, namely:

- habitat loss (temporary and permanent);
- disturbance (e.g. noise, vibration, movement and lighting);
- changes in water quality (e.g. accidental spillage and sediment delivery); and
- changes in coastal geomorphology (e.g. tidal flows).

During a site visit in June 2019, two additional potential impacts as a result of the operational flood walls were suggested by NatureScot: an increase in predation of qualifying species by raptors; and shading effects along the flood defences.

Once operational, the flood defences could provide increased opportunities for raptors to predate qualifying species of the SPA, by enabling hunting raptors to use the flood defence structures as a visual barrier allowing close approach to prey species. This effect is, however, considered to be negligible given the low numbers of birds of the raptor species with potential to make use of the flood defence wall in the area. No raptors were recorded during the 2015/16 and 2016/17 bird surveys. During the 2022/23 surveys, raptors were observed infrequently (15 records between August and March) and these records were primarily of raptors flying over grassland areas where there is suitable habitat for small mammals. Sparrowhawk and merlin are the only raptor species likely to be present in the vicinity of the Forth Estuary that regularly make use of linear features whilst hunting to obscure their presence from prey in ambush attacks. Linear features adjacent to the Forth Estuary are already present: there is considerable infrastructure, pipework, fenceline and bunds associated with the petrochemical plant and Port of Grangemouth. Bands of trees, scrub and tall vegetation also line large sections of the estuary edge. Therefore, it is considered extremely unlikely that the new flood walls would result in a reduction in the numbers of prey species via this effect.

Artificial shading could indirectly affect birds by impacting their feeding resource by reducing species richness and abundance of benthic assemblages. However, the flood defences are to be constructed at the edge of the estuary mostly on verge habitat and any shading would be localised to areas where birds do not forage; the majority of species present in the estuary forage in the lower reaches of the shore and mudflats. Therefore, no potential impact is anticipated as a result of shading.

Potential changes in water quality from pollution events (e.g. accidental spillage and sediment delivery) during construction have the potential to have an indirect effect on qualifying species of the SPA and Ramsar through deterioration of mudflat habitats, and thus the feeding resource for waders and waterfowl. However, best practice measures which are intrinsic to the project, including production of a Pollution Prevention Plan, will mitigate any potential changes in water quality. The Pollution Prevention Plan will include, but will not be limited to, the setting back of stockpiles, concrete mixing and washing areas, and the storage of chemicals, fuels and oil more than 10m from the estuary. The plan will be based on those produced for previous projects, including previous flood protection schemes and projects adjacent to designated sites, and will be reviewed by suitably experienced individuals to provide confidence in its effectiveness. The plan will form part of the CEMP and will be a specification in the contract for the Scheme. The plan will also be submitted to SEPA for approval prior to construction. In addition, best practice construction methods will be used, including the use of appropriate pollution controls (i.e. Guidance for Pollution Prevention (GPPs)). It will be a contract requirement to protect the water environment during construction and operational changes in water quality are not considered to differ significantly from the existing conditions. Therefore, no implications to qualifying species are predicted and changes in water quality have not been considered further within this HRA.

Construction areas and flood defences would encroach on the Firth of Forth estuary. As a result, there is potential for changes in coastal geomorphology. Chapter 10 (Water Environment), and in particular Appendix C10.2 (Estuarine Geomorphology), of the EIA Report (Jacobs, 2024) assessed the potential impacts of the Scheme on the water environment. The assessments from these documents have been summarised in

Appendix D (Estuarine Geomorphology) of this HRA. During construction, there could be temporary and localised changes of the following: speed and direction of tidal flows, morphology due to disturbance of intertidal areas, and subtidal morphology. During construction, there could be temporary morphological changes and changes in flow speeds and directions, localised to the works, considered to be of minor and negligible magnitude. During operation, there would be a small loss of intertidal habitat under the footprint of the defences and negligible localised changes of estuarine morphology. No potential construction or operational impacts were identified as significant in the EIA Report assessment (the methods and criteria for the assessment are included within Appendix D). In the context of this HRA, no potential for LSE is identified during construction or operation with regards to changes in coastal geomorphology. Therefore, changes in coastal geomorphology have not been considered further within this HRA.

The potential impacts were used to identify LSEs on the European/Ramsar sites in terms of the sites' conservation objectives from the construction and operation activities of the Scheme, presented in Section 2 (The Scheme). Table 3.2 provides the screening of European/Ramsar sites with potential for LSEs from the construction and/or operation of the Scheme.

Potential in combination effects with other projects or plans are considered in Section 3.4. In-Combination Effects.

As no LSEs have been identified due to changes in water quality or coastal geomorphology, the following conservation objective will be maintained and is not considered further in the assessment:

- To ensure for the qualifying species that the following are maintained in the long term: structure, function and supporting processes of habitats supporting the species.

All other conservation objectives (presented in Table 3.2) have been considered in the assessment.

Table 3.2: Screening of European/Ramsar sites with potential for LSEs from the construction and/or operation of the Scheme

Conservation Objectives	Distance/Connectivity to Scheme	Qualifying Interests	Potential Effects and Commentary	Screening Conclusion
UK9004411 / 8499 Firth of Forth SPA				
To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained; and To ensure for the qualifying species that the following are maintained in the long term: • population of the species as a viable component of the site • distribution of the species within site • distribution and extent of habitats supporting the species • structure, function and supporting processes of habitats supporting the species • no significant disturbance of the species	The Scheme is partly within the Firth of Forth SPA.	• bar-tailed godwit*, non-breeding • golden plover*, non-breeding • knot*, non-breeding • pink-footed goose*, non-breeding • red-throated diver*, non-breeding • redshank*, non-breeding • Sandwich tern, passage • shelduck*, non-breeding • Slavonian grebe*, non-breeding • turnstone, non-breeding Waterfowl assemblage (non-breeding): • common scoter • cormorant • curlew • dunlin • eider • goldeneye • great crested grebe • grey plover • lapwing	<u>Habitat Loss</u> The Scheme has the potential for temporary habitat loss of up to 0.43ha, of which 0.25ha is mudflat habitat, within the SPA. The Scheme could result in the permanent alteration of up to 1.15ha within the SPA, of which 0.59ha is mudflat habitat. This may result in localised fragmentation/loss of habitat for qualifying species of the SPA, especially those which rely on intertidal areas at the estuary edge as their primary habitat type over winter.	LSEs identified during construction and operation. Requirement to progress to AA (HRA Stage 2).
			<u>Disturbance (Noise, Vibration and Visual)</u> There is potential for disturbance to qualifying species of the SPA which are found within the inner Forth, during the construction and maintenance of the Scheme from temporary lighting, piling works, and human and vehicle movements. With the exception of maintenance works, disturbance during the operation of the Scheme is not considered to differ from that currently experienced within the area.	LSEs identified during construction and maintenance. Requirement to progress to AA (HRA Stage 2).

Conservation Objectives	Distance/Connectivity to Scheme	Qualifying Interests	Potential Effects and Commentary	Screening Conclusion
		• long-tailed duck • mallard • oystercatcher • red-breasted merganser • ringed plover • scaup • velvet scoter • wigeon		
UK13017 / 8424 Firth of Forth Ramsar				
The Ramsar Convention's mission is '*the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world*'.	The Scheme is partly within the Firth of Forth Ramsar.	• bar-tailed godwit*, non-breeding • goldeneye*, non-breeding • golden plover*, non-breeding • knot*, non-breeding • pink-footed goose*, non-breeding • red-throated diver*, non-breeding • redshank*, non-breeding • Sandwich tern, passage • shelduck*, non-breeding • Slavonian grebe*, non-breeding • turnstone*, non-breeding Waterfowl assemblage (non-breeding): • common scoter • cormorant	<u>Habitat Loss</u> The Scheme has the potential for temporary habitat loss of up to 0.43ha, of which 0.25ha is mudflat habitat, within the SPA. The Scheme could result in the permanent alteration of up to 1.15ha within the Ramsar site, of which 0.59ha is mudflat habitat. This may result in localised fragmentation/loss of habitat for qualifying species of the SPA, especially those which rely on intertidal areas at the estuary edge as their primary habitat type over winter.	LSEs identified during construction and operation. Requirement to progress to AA (HRA Stage 2).
			<u>Disturbance (Noise, Vibration and Visual)</u> There is potential for disturbance to qualifying species of the Ramsar which are found within the inner Forth, during the construction and maintenance of the Scheme from temporary lighting, piling works, and human and vehicle movements. With the exception of maintenance works, disturbance during the operation of the Scheme is not considered to differ from that currently experienced within the area.	LSEs identified during construction and maintenance. Requirement to progress to AA (HRA Stage 2).

Conservation Objectives	Distance/Connectivity to Scheme	Qualifying Interests	Potential Effects and Commentary	Screening Conclusion
		• curlew • dunlin • eider • great crested grebe • grey plover • lapwing • long-tailed duck • mallard • oystercatcher • red-breasted merganser • ringed plover • scaup • velvet scoter • wigeon		
UK0030263 / 8367 River Teith SAC				
To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to achieving favourable conservation status for each of the qualifying features; and To ensure for the qualifying species that the following are maintained in the long term: • population of the species, including range of genetic types for salmon, as a viable component of the site • distribution of the species within site	The SAC is located approximately 18km in a straight line, and 31km following the hydrological connection, upstream of the Scheme. Qualifying species of the SAC will migrate through the Firth of Forth.	• Atlantic salmon • brook lamprey • river lamprey • sea lamprey	<u>Habitat Loss</u> No land-take from the SAC is required for the Scheme. Furthermore, there will be no loss or severance of supporting habitat for lamprey species or Atlantic salmon as all the works are localised to the estuary edge around The Port of Grangemouth and petrochemical plant. No potential for LSE during construction or operation with regards to habitat loss is identified.	No potential for LSE during construction or operation. AA (HRA Stage 2) is not required.
			<u>Disturbance (Noise, Vibration and Visual)</u> The Scheme is located approximately 18km in a straight line, and 31km following the hydrological connection, downstream of the SAC, however lamprey species and Atlantic salmon will migrate through the Firth of Forth. The Firth of Forth is a wide estuary and the Scheme is localised to the estuary edge around the Port of Grangemouth and petrochemical plant; during construction a sufficient migratory corridor would be maintained. Disturbance during the operation of the Scheme is not considered to differ from that currently experienced within the area. No potential for LSE during construction or operation with regards to disturbance is identified.	No potential for LSE during construction or operation. AA (HRA Stage 2) is not required.

Conservation Objectives	Distance/Connectivity to Scheme	Qualifying Interests	Potential Effects and Commentary	Screening Conclusion
• distribution and extent of habitats supporting the species • structure, function and supporting processes of habitats supporting the species • no significant disturbance of the species				
UK9004171 / 8500 Forth Islands SPA				
To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained; and To ensure for the qualifying species that the following are maintained in the long term: • population of the species as a viable component of the site • distribution of the species within site • distribution and extent of habitats supporting the species • structure, function and supporting processes of habitats supporting the species • no significant disturbance of the species	The SPA is located approximately 16km in a straight line, and 17km following the hydrological connection, downstream of the Scheme. Qualifying bird species of the SPA, mainly those that nest on Long Craig Island, may use the Firth of Forth in the vicinity of the Scheme for foraging.	• Arctic tern, breeding • common tern, breeding • cormorant, breeding • gannet, breeding • guillemot*, breeding and non-breeding • herring gull*, breeding and non-breeding • kittiwake*, breeding and non-breeding • lesser black-backed gull, breeding • roseate tern, breeding • Sandwich tern, breeding • shag*, breeding and non-breeding Waterfowl assemblage, breeding: • puffin, breeding • razorbill, breeding	<u>Habitat Loss</u> Forth Islands SPA consists of a series of islands supporting important numbers of breeding seabirds in the Firth of Forth. No permanent land-take from the SPA is required for the Scheme. The Scheme has the potential for temporary habitat loss of up to 0.43ha, of which 0.25ha is mudflat habitat, within the Forth estuary. The Scheme could result in the permanent alteration of up to 1.15ha within the Forth estuary, of which 0.59ha is mudflat habitat. The loss of this supporting habitat which could be used for foraging, may result in localised fragmentation/loss of habitat for qualifying species of the Forth Islands SPA. The key species for this potential impact are common and roseate terns which nest on Long Craig Island. Due to the small areas of habitat loss and wide availability of alternative foraging habitats in the Forth estuary for those species that could be affected by the loss of foraging habitat, no potential for LSE during construction or operation with regards to habitat loss is identified.	No potential for LSE during construction or operation. AA (HRA Stage 2) is not required.
			<u>Disturbance (Noise, Vibration and Visual)</u> The SPA is designated for supporting important numbers of breeding seabirds. The nearest island of the SPA (Long Craig Island) is located approximately 16km from the Scheme which supports nesting common and roseate terns. None of the qualifying species will be disturbed as a result of the Scheme whilst breeding on the islands. Individuals from the tern breeding colony on Long Craig Island may be disturbed should they forage in the open waters near the Scheme. However, due to the wide availability of alternative foraging habitats in the Forth estuary no potential for LSE during construction with regards to disturbance is identified.	No potential for LSE during construction or operation. AA (HRA Stage 2) is not required.

Conservation Objectives	Distance/Connectivity to Scheme	Qualifying Interests	Potential Effects and Commentary	Screening Conclusion
			Disturbance during the operation of the Scheme is not considered to differ from that currently experienced within the area.	
UK9004451 / 8668 Imperial Dock Lock, Leith SPA				
To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained; and To ensure for the qualifying species that the following are maintained in the long term: • population of the species as a viable component of the site • distribution of the species within site • distribution and extent of habitats supporting the species • structure, function and supporting processes of habitats supporting the species • no significant disturbance of the species	The SPA is located approximately 30km downstream of the Scheme. Common tern may use the Firth of Forth in the vicinity of the Scheme for foraging. Hydrologically connected to the Scheme.	• common tern, breeding	<u>Habitat Loss</u> Imperial Dock Lock, Leith SPA supports the largest common tern colony in the Firth of Forth. No permanent land-take from the SPA is required for the Scheme. The Scheme has the potential for temporary habitat loss of up to 0.43ha, of which 0.25ha is mudflat habitat, within the Forth estuary. The Scheme could result in the permanent alteration of up to 1.15ha within the Forth estuary, of which 0.59ha is mudflat habitat. The loss of this supporting habitat which could be used for foraging, may result in localised fragmentation/loss of habitat for qualifying species of Imperial Dock Lock, Leith SPA. Due to the small areas of habitat loss and wide availability of alternative foraging habitats in the Forth Estuary for common tern, no potential for LSE during construction or operation with regards to habitat loss is identified.	No potential for LSE during construction or operation. AA (HRA Stage 2) is not required.
			<u>Disturbance (Noise, Vibration and Visual)</u> The SPA is designated for supporting important numbers of common tern. The SPA is located approximately 30km from the Scheme. No qualifying species will be disturbed as a result of the Scheme whilst breeding at Leith Dock. Individuals from the breeding colony at Leith Dock may be disturbed should they forage near the Scheme. However, due to the wide availability of alternative foraging habitats in the Forth Estuary and the location of the works in relation to the SPA, no potential for LSE during construction with regards to disturbance is identified. Disturbance during the operation of the Scheme is not considered to differ from that currently experienced within the area.	No potential for LSE during construction or operation. AA (HRA Stage 2) is not required.
UK0030172 / 8278 Isle of May SAC				

Conservation Objectives	Distance/Connectivity to Scheme	Qualifying Interests	Potential Effects and Commentary	Screening Conclusion
To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained, and the site makes an appropriate contribution to achieving favourable conservation status for each of the qualifying features; and To ensure for the qualifying species that the following are maintained in the long term: • population of the species as a viable component of the site • distribution of the species within site • distribution and extent of habitats supporting the species • structure, function and supporting processes of habitats supporting the species • no significant disturbance of the species To avoid deterioration of the qualifying habitat thus ensuring that the integrity of the site is maintained, and the site makes an appropriate contribution to achieving favourable conservation status for each of the qualifying features; and To ensure for the qualifying habitat that the following are maintained in the long term: • extent of the habitat on site • distribution of the habitat within site	The SAC is located approximately 70km downstream of the Scheme. Hydrologically connected to the Scheme.	• grey seal • reefs	<u>Habitat Loss</u> The Isle of May is located in the north of the outer Firth of Forth and supports a breeding colony of grey seal and the Annex I habitat, reefs. No land-take from the SAC is required for the Scheme. Furthermore, there will be no loss or severance of supporting habitat for grey seal as all the works are localised to the estuary edge around the Port of Grangemouth and petrochemical plant. No potential for LSE during construction or operation with regards to habitat loss is identified.	No potential for LSE during construction or operation. AA (HRA Stage 2) is not required.
			<u>Disturbance (Noise, Vibration and Visual)</u> The SAC is designated for breeding grey seal and is located approximately 70km from the Scheme. Grey seal will not be disturbed as a result of the Scheme whilst breeding in or near the SAC. Grey seal could only be disturbed if they forage or travel near to the Scheme. However, grey seals favour more exposed coasts and islands closest to the open sea (NatureScot, 2020), and no designated haul out sites are located in the Scheme area (Marine Scotland, 2020). Therefore, grey seal will not be disturbed by works taking place in the inner Forth. No potential for LSE during construction with regards to disturbance is identified. Disturbance during the operation of the Scheme is not considered to differ from that currently experienced within the area.	No potential for LSE during construction or operation. AA (HRA Stage 2) is not required.

Conservation Objectives	Distance/Connectivity to Scheme	Qualifying Interests	Potential Effects and Commentary	Screening Conclusion
• structure and function of the habitat • processes supporting the habitat • distribution of typical species of the habitat • viability of typical species as components of the habitat • no significant disturbance of typical species of the habitat				
UK9020316 / 10478 Outer Firth of Forth and St Andrews Bay Complex SPA				
To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, subject to natural change, thus ensuring that the integrity of the site is maintained in the long-term and it continues to make an appropriate contribution to achieving the aims of the Birds Directive for each of the qualifying species. This contribution will be achieved through delivering the following objectives for each of the site's qualifying features: a) Avoid significant mortality, injury and disturbance of the qualifying features, so that the distribution of the species and ability to use the site are maintained in the long-term; b) To maintain the habitats and food resources of the qualifying features in favourable condition.	The SPA is located approximately 18km downstream of the Scheme. Hydrologically connected to the Scheme.	• Arctic tern, breeding • black-headed gull*, non-breeding • common gull*, non-breeding • common tern, breeding • eider, non-breeding • gannet, breeding • goldeneye, non-breeding • guillemot*, breeding and non-breeding • herring gull*, breeding and non-breeding • kittiwake*, breeding and non-breeding • little gull, non-breeding • long-tailed duck, non-breeding • razorbill*, breeding and non-breeding • red-breasted merganser, non-breeding	<u>Habitat Loss</u> The site is located to the east of the Forth Bridges and is intended to protect marine foraging areas. No land-take from the SPA is required for the Scheme. Furthermore, there will be no loss or severance of supporting habitat for qualifying species as all the works are localised to the estuary edge around the Port of Grangemouth and petrochemical plant. No potential for LSE during construction or operation with regards to habitat loss is identified based on the SPA's position and function.	No potential for LSE during construction or operation. AA (HRA Stage 2) is not required.
			<u>Disturbance (Noise, Vibration and Visual)</u> The marine area included in the SPA is located approximately 18km east from the Scheme and encompasses the marine environment into the outer estuary. Qualifying species could be disturbed if utilising marine foraging areas adjacent to the Scheme. However, as the works are localised to the estuary edge, disturbance to marine foraging areas will be limited and therefore disturbance to foraging birds using the marine environments is unlikely. Disturbance during the operation of the Scheme is not considered to differ from that currently experienced within the area.	No potential for LSE during construction or operation. AA (HRA Stage 2) is not required.

Conservation Objectives	Distance/Connectivity to Scheme	Qualifying Interests	Potential Effects and Commentary	Screening Conclusion
		• red-throated diver, non-breeding • shag*, breeding and non-breeding • Slavonian grebe, non-breeding • velvet scoter, non-breeding Waterfowl assemblage, breeding: • puffin, breeding Waterfowl assemblage, non-breeding: • common scoter, non-breeding • Manx shearwater, non-breeding	No potential for LSE during construction or operation with regards to disturbance is identified.	
UK9004441 / 9184 Slamannan Plateau SPA				
To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained; and To ensure for the qualifying species that the following are maintained in the long term: • population of the species as a viable component of the site • distribution of the species within site • distribution and extent of habitats supporting the species	The SPA is located approximately 5km southwest from the Scheme. Hydrologically connected to the Scheme (River Avon).	• Taiga bean geese, non-breeding	<u>Habitat Loss</u> No land-take from the SPA is required for the Scheme. Furthermore, there will be no loss or severance of supporting habitat for qualifying species as all the works are localised to the estuary edge around the Port of Grangemouth and petrochemical plant; habitat not used by bean goose. No potential for LSE during construction or operation with regards to habitat loss is identified.	No potential for LSE during construction or operation. AA (HRA Stage 2) is not required.
			<u>Disturbance (Noise, Vibration and Visual)</u> The SPA is located 5km southwest of the Scheme. Qualifying species could be disturbed if utilising the estuary adjacent to the Scheme. Taiga bean geese were not recorded during the surveys. The dispersal of individuals from the Slamannan Plateau *'is unknown and considered unlikely*' (Hearn, 2004) and there is very little fluctuation in wintering bird counts at the site until spring migration commences. Taiga been geese have displayed high fidelity to wintering sites elsewhere in Europe (Nilsson and Persson, 1991).	No potential for LSE during construction or operation. AA (HRA Stage 2) is not required.

Conservation Objectives	Distance/Connectivity to Scheme	Qualifying Interests	Potential Effects and Commentary	Screening Conclusion
• structure, function and supporting processes of habitats supporting the species • no significant disturbance of the species			No potential for LSE during construction or operation with regards to disturbance is identified.	
UK9004111 / 8530 Loch Leven SPA				
To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained; and To ensure for the qualifying species that the following are maintained in the long term: • population of the species as a viable component of the site • distribution of the species within site • distribution and extent of habitats supporting the species • structure, function and supporting processes of habitats supporting the species • no significant disturbance of the species	The SPA is located approximately 24km northeast from the Scheme. Cormorant from Loch Leven are known to travel to the Firth of Forth (Wright, 2003). The River Leven flows from Loch Leven to the Firth of Forth, downstream of the Scheme, at Leven.	• pink-footed goose, non-breeding • whooper swan, non-breeding Waterfowl assemblage, non-breeding: • cormorant • gadwall • goldeneye • pochard • shoveler • teal • tufted duck	<u>Habitat Loss</u> No land-take from the SPA is required for the Scheme. However, the Scheme has the potential for temporary habitat loss of up to 0.43ha, of which 0.25ha is mudflat habitat, within the Forth estuary. The Scheme could result in the permanent alteration of up to 1.15ha within the Forth estuary, of which 0.59ha is mudflat habitat. The loss of this supporting habitat may result in localised fragmentation/loss of habitat for qualifying species of the SPA should they utilise the Firth of Forth. Cormorant is known travel between Loch Leven and other sites, including the Firth of Forth (Wright, 2003). No other individuals of the qualifying species of Loch Leven SPA are known to travel between Loch Leven and the Firth of Forth.	LSEs identified during construction and operation. Requirement to progress to AA (HRA Stage 2).
			<u>Disturbance (Noise, Vibration and Visual)</u> The SPA is designated for supporting important numbers of wintering birds. None of the qualifying species will be disturbed as a result of the Scheme whilst wintering on Loch Leven. However, individuals may be disturbed during construction and maintenance works if visiting the Firth of Forth from Loch Leven. With the exception of maintenance works, disturbance during the operation of the Scheme is not considered to differ from that currently experienced on the Firth of Forth.	LSEs identified during construction and maintenance. Requirement to progress to AA (HRA Stage 2).
UK13033 / 8436 Loch Leven Ramsar				
The Ramsar Convention's mission is '*the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world*'.	The SPA is located approximately 24km northeast from the Scheme. The River Leven flows from Loch Leven to the Firth of Forth, downstream of the Scheme, at Leven.	• eutrophic loch • pink-footed goose, non-breeding • shoveler, non-breeding • whooper swan, non-breeding	<u>Habitat Loss</u> No land-take from the Ramsar is required for the Scheme. However, the Scheme has the potential for temporary habitat loss of up to 0.43ha, of which 0.25ha is mudflat habitat, within the Forth estuary. The Scheme could result in the permanent alteration of up to 1.15ha within the Forth estuary, of which 0.59ha is mudflat habitat. The loss of this supporting habitat may result in localised fragmentation/loss of habitat for qualifying species of the Ramsar site should they utilise the Firth of Forth. Cormorant is known travel between Loch Leven and other sites,	LSEs identified during construction and operation. Requirement to progress to AA (HRA Stage 2).

Conservation Objectives	Distance/Connectivity to Scheme	Qualifying Interests	Potential Effects and Commentary	Screening Conclusion
		Waterfowl assemblage (non-breeding): • cormorant • gadwall • goldeneye • pochard • teal • tufted duck	including the Firth of Forth (Wright, 2003). No other individuals of the qualifying species of Loch Leven Ramsar site are known to travel between Loch Leven and the Firth of Forth.	
			<u>Disturbance (Noise, Vibration and Visual)</u> The Ramsar is designated for supporting important numbers of wintering birds. None of the qualifying species will be disturbed as a result of the Scheme whilst wintering on Loch Leven. However, individuals may be disturbed if visiting the Firth of Forth from Loch Leven. Disturbance during the operation of the Scheme is not considered to differ from that currently experienced within the area.	LSEs identified during construction and maintenance. Requirement to progress to AA (HRA Stage 2).

*species also an assemblage qualifier.

As stated in Section 1.2.3, an AA is required where any plan or project is likely to have a significant effect either individually or in combination with other plans or projects. This assessment is required prior to AA (i.e. at identification of LSEs) to determine whether effects which may not be likely or significant may become so in combination. The assessment also checks for adverse and or/residual effects of other plans or projects. Thus, the assessment considers both the potential effects of other plans published for consultation and projects seeking consent and any ongoing negative effects of completed plans or projects.

A full list of projects and plans assessed can be found in Appendix E (In-Combination Assessment). NatureScot noted that the Musselburgh Flood Protection Scheme (Musselburgh FPS) should be considered within the in-combination assessment, due to the scale of the project and its proximity to the Firth of Forth SPA. Information on the Musselburgh Flood Protection is provided below.

3.3.1 Musselburgh Flood Protection Scheme

This proposed scheme will consist of a combination of direct defences (walls and embankments), pumping stations and bridge removal/replacement in Musselburgh town centre along with flood alleviation measures in the upper catchment. Defences for the proposed Musselburgh FPS are to be constructed along the River Esk, which flows through the town, and along the coastal boundary of the Firth of Forth SPA.

An options appraisal process has been undertaken and the preferred scheme was approved by the East Lothian Council's cabinet on 21 January 2020. The Outline Design for the scheme was presented to East Lothian Council on 23rd January 2024 and the scheme documents (including EIA Report) were published on 21st March 2024 (East Lothian Council and Jacobs, 2024). The HRA for the scheme is in development and there is currently no information available on this specific assessment as all data and drafts are proprietary to East Lothian Council until the documentation is finalised and made available to other parties. However, based on the information provided within the Musselburgh FPS EIA Report, it is understood that the scheme could result in a small area of habitat loss from the Firth of Forth SPA and could cause disturbance to qualifying species during construction.

In relation to habitat loss, the Musselburgh FPS EIA Report identified that there could be up to 2.14ha of temporary habitat loss from the Firth of Forth SPA during construction and up to 4.3ha of permanent habitat loss as a result of the scheme, which would be a small percentage of habitat available to qualifying species in the Firth of Forth estuary. Habitats lost consist of intertidal sand, boulders and rocks, some of the existing seawall, and small areas of grassland and dune habitats. No loss of mudflat or saltmarsh habitat from the Musselburgh FPS has been identified and therefore there will be no loss of foraging habitat for the qualifying species of the Firth of Forth SPA. With the implementation of mitigation identified in the Musselburgh FPS EIA Report, no significant residual effects were predicted on the Firth of Forth SPA for temporary or permanent habitat loss. Habitat loss at Musselburgh FPS is not predicted to have any in-combination effects with the Scheme.

In relation to roosting birds, construction works within the vicinity of the Firth of Forth SPA could feasibly take place for both flood protection schemes at the same time. The Musselburgh FPS EIA Report states '*construction would not proceed along the entire length of the scheme adjacent to the SPA at any one time; therefore, temporary disturbance would be limited to discrete working areas according to the phasing of the project'*. It notes that standard best practise construction mitigation measures will be implemented to reduce disturbance, including soft starts of machinery and noise/visual barriers. Additionally, mitigation item E8 states '*works on the sea wall will be restricted to a maximum length of 500m at any one time unless otherwise agreed with NatureScot. Construction along the sea wall would only be carried out during summer months (approximately April to Sept) in any one year unless otherwise agreed with NatureScot*.' With the implementation of mitigation identified in the Musselburgh FPS EIA Report, no significant residual effects were predicted on the Firth of Forth SPA for disturbance during construction.

In relation to the potential for in-combination effects due to interchange of birds *between* schemes, the Musselburgh FPS is located approximately 39km from the Scheme. Information available on the wintering foraging behaviours of qualifying species of the Firth of Forth SPA indicates that, except for cormorant, birds are unlikely to regularly travel this distance. For example, the core range for non-breeding pink-footed goose is 15km to 20km (SNH, 2016a). Additionally, NatureScot (2023m) guidance for offshore windfarms recommends that

impact pathways be considered within a 15km buffer '*for all inshore wintering waterfowl qualifying features of marine SPAs*'. Given that this 15km buffer has been applied to a range of species and covers all potential pathways, including disturbance, it is reasonable to also apply this buffer to disturbance pathways for the Scheme. The distance between the GFPS and MFPS (approximately 39km) comfortably exceeds the distances that qualifying species of the Firth of Forth SPA are known to typically travel whilst at their non-breeding grounds. It is therefore reasonable to assume that there will be very limited interchange of birds between the two schemes – birds potentially affected (e.g. disturbed whilst roosting) by construction at one scheme are very unlikely to also experience effects from the other scheme. No in-combination effects via interchange of birds between schemes are identified.

Cormorants are known to travel further distances between sites than other species during the non-breeding season, up to 45km in a day depending on food availability (Forrester et al., 2007). Cormorants (from either the Firth of Forth SPA or the Loch Leven SPA populations) roosting or foraging around either scheme could therefore potentially relocate to the other scheme and be similarly disturbed. Cormorant has a low sensitivity to human disturbance - foraging and/or roosting/loafing cormorants, if disturbed at either or both schemes, have abundant nearby alternative available suitable habitat. No in-combination effects on cormorant are identified.

In relation to in-combination effects due to disturbance at *either* scheme, birds affected by disturbance at Grangemouth FPS are duly addressed via the proposed mitigation measures and compensatory measures as described within this document. Birds which might experience disturbance effects at Musselburgh FPS are likely to be similarly dealt with at the location of the Musselburgh site. Therefore, no in-combination effects on the SPA are identified.

3.4 Screening Conclusion

As identified in the screening in Table 3.2, the Scheme has the potential for LSEs due to habitat loss and disturbance/displacement on the Firth of Forth SPA and Ramsar site, and Loch Leven SPA and Ramsar site. Therefore, an Appropriate Assessment (HRA Stage 2) is required. No LSEs on these sites have been identified due to changes in water quality or changes in coastal geomorphology.

No LSEs were identified on the River Teith SAC, Forth Islands SPA, Imperial Dock Lock, Leith SPA, Isle of May SAC, Outer Firth of Forth and St Andrews Bay Complex SPA, or Slamannan Plateau SPA. Therefore, there is no requirement for further consideration for these European sites either alone or in combination with other plans and projects within the HRA process.

No in-combination effects are predicted with any other plans or projects. No additional LSEs are identified via in-combination effects to those presented in Table 3.2.

4. Stage 2 (Appropriate Assessment)

4.1 Introduction

This section forms the Stage 2 (Appropriate Assessment (AA)) step of the HRA process which was identified as required in Stage 1 (Screening). The AA considers the effect of the project or plan, either alone or in combination with other projects or plans, on the integrity of the European/Ramsar site, with respect to the site's structure and function, and its conservation objectives. Specific conservation objectives are not available for Ramsar sites. However, Scottish Government policy states that '*Where Ramsar interests coincide with Natura qualifying interests protected under an SPA or an SAC, as the case may be, the interests are thereby given the same level of (legal) protection as Natura sites*' (Scottish Government, 2019) and therefore the same objectives for SPAs are applicable (SNH, 2018a). As both the Firth of Forth SPA and Ramsar site occupy the same area and have the same species listed as qualifying species, the assessment of effects will be against the Firth of Forth SPA's conservation objectives. The assessment of effects on Loch Leven SPA and Ramsar site will also be against Loch Leven's SPA conservation objectives as the two sites occupy the same area and have the same species listed as qualifying species.

The approach adopted for this AA is to focus on the avoidance of effects on European/Ramsar site integrity in the first instance. Where avoidance is not possible, appropriate mitigation measures are proposed to reduce effects in order to avoid adverse effects on site integrity (AESI). Where, after an AA, an AESI may remain, measures to offset the impact may be required (compensation) where the Competent Authority deems that the Scheme must be delivered for Imperative Reasons of Overriding Interest (IROPI) and there are no alternative solutions.

4.2 Aims

The following sections summarise the information used to inform the AA. Information on the distribution, abundance and behaviour of bird species and habitats within the Firth of Forth was gathered through a combination of desk study, bird surveys, and biotope surveys. Information on the baseline noise levels of the site and noise levels during ground investigation (GI) works was also collected along the estuary edge, in tandem with bird monitoring to assess bird reactions to noise stimuli. The aim of the Stage 2 HRA is to assess the potential for effects on the Firth of Forth SPA/Ramsar site, and Loch Leven SPA/Ramsar site from the Scheme and to identify appropriate mitigation to reduce these impacts and avoid AESI. To achieve this, the following will be undertaken:

- assessment of the usage of the Firth of Forth area by bird species in relation to the Scheme, thus determining the ecological importance to the qualifying bird species of the areas potentially affected;
- analysis of bird data to determine the implication from the LSEs resulting from habitat loss and disturbance as a result of the Scheme;
- determination of the severity of the identified effects predicted on the qualifying species;
- assessment and analysis of the potential for AESI of the Firth of Forth SPA/Ramsar site, and Loch Leven SPA/Ramsar site;
- specification of suitable mitigation measures to avoid AESI; and
- identification of any remaining implications for the Firth of Forth SPA /Ramsar site and Loch Leven SPA/Ramsar site.

4.3 Ornithological Assessment Approach

This section sets out the ornithology data gathered and describes how it has been used to inform the AA. The data used in the assessment focusses on bird survey Sectors 4 – 11, which are adjacent to the Scheme (Figure 10). Surveys conducted in 2015/16 and 2016/17 covered a larger area (Sectors 1 – 16) as the Scheme design had not yet been refined. Further details on the ornithology information can be found in Appendix B (Ornithological Information), which details the bird survey methodologies and presents data on the abundance and distribution

of bird species within the study area. The data were used to identify qualifying species that occur within the study area and could be affected by the Scheme.

Assessment of the bird data in relation to effects pathways for the Firth of Forth SPA/Ramsar site and Loch Leven SPA/Ramsar site is presented within Section 4.7 and Section 4.8 respectively.

4.3.1 Habitat Loss

Habitat loss as a result of the Scheme has been identified as having potential effects (i.e. loss of roosting and/or foraging habitat) on qualifying species of the Firth of Forth SPA/Ramsar site and Loch Leven SPA/Ramsar site (Section 3.3 Screening). The Zone of Influence (ZoI) for temporary and permanent habitat loss encompasses the area directly under the Scheme footprint during construction and operation – these areas have been identified by the design team using AutoCAD and GIS software. Temporary habitat loss during construction was calculated by subtracting the Permanent Works Footprint shapefile from the Site Boundary (Land Affected) shapefile, which includes all working areas, haul roads and indicative compound sites. All habitat under the Permanent Works Footprint has been identified as habitat permanently altered at the operational stage of the Scheme. The entire Site Boundary of the Scheme is unlikely to be unavailable at the same time as construction will be phased over a number of years (Section 2.4.5). This loss of habitat could result in the loss, or localised fragmentation, of foraging and/or roosting habitat due to installation of the flood defences and could impact birds which rely on intertidal areas at the estuary edge, including their displacement.

4.3.2 Disturbance

Noise and visual impacts from the Scheme have been identified as having potential effects (disturbance potentially leading to displacement) to qualifying species of the Firth of Forth SPA/Ramsar site and Loch Leven SPA/Ramsar site (Section 3.3 Screening).

The ZoI (for noise and visual disturbances) demarcates the area within which birds could be disturbed/displaced. The bird data shows the numbers of birds within this ZoI which could be disturbed or displaced, the locations at which aggregations of birds occur, during which period of the year and at what tidal state. In order to establish a ZoI around visual and noise disturbances and potential impacts to qualifying species an understanding of potential disturbance distances for each affected species is required.

The Waterbird Disturbance Mitigation Toolkit (Cutts et al., 2013) suggests a 300m ZoI for noise and visual disturbances for wintering waterbirds. As part of the ornithological investigation for this HRA, the suitability of this 300m ZoI distance has been tested for each of the qualifying species individually by investigating available literature. In general, 300m is a suitable ZoI for many of the key species in this assessment, however on consideration of the NatureScot commissioned Research Report 1283 – Disturbance Distances Review: An updated literature review of disturbance distances of selected bird species (Goodship and Furness, 2022), a more precautionary distance of 650m has been adopted for visual disturbance of select, more sensitive species. A summary of the review conducted for this HRA, and the disturbance distance thresholds for each qualifying species based on a range of academic literature and research studies, can be found in Table 4.1.

Table 4.1: Disturbance distance / response threshold for qualifying species of the Firth of Forth SPA/ Ramsar site, including cormorant, a qualifying species of the Loch Leven SPA/Ramsar with connectivity to the Firth of Forth.

Species	Discussion	Zone of Influence (ZoI) Validity
300m ZoI for noise and visual disturbance		
Bar-tailed godwit (300m ZoI)	Bar-tailed godwit do not breed in the UK, and therefore only have the potential to be disturbed on foraging and roosting grounds during the non-breeding season. A maximum Flight Initiation Distance (FID)[1] value recorded for bar-tailed godwit is 450m when approached by a pedestrian (Laursen et al., 2005), however the majority of FID values are less than a mean of 200m when approached by a pedestrian. Other records showed a mean FID of 85m and a minimum/maximum of 32m – 225m to surveyors walking along the shoreline in the UK (Collop et al., 2016), with other references showing mean FIDs for bar-tailed godwit as 39m to surveyors walking in an estuary (Brett, 2012). Bar-tailed godwit at Musselburgh Lagoons are more likely than other waders to be disturbed by people and aircraft (Furness, 1973), and it has been noted that bar-tailed godwit are more prone to natural causes of disturbance (e.g., predators) than human disturbance. Birds that react to human disturbance are often flushed by tractors and/or trucks (Verslujis, 2011).	Bar-tailed godwit has been assessed by Goodship and Furness (2022) as having a medium sensitivity to disturbance and suggested a buffer zone of 200m-300m for this species. Therefore, a 300m ZoI for disturbance is considered suitable.
Cormorant (300m ZoI)	Cormorant have been shown to have a mean FID range of 74m – 77.9m to pedestrians and 7.7m to 23.5m to a car at a disturbed site for seaweed harvesting during the non-breeding season. Cormorant have also been shown to have escape distances[1] with a mean of 193m with an unobstructed view to the cause of disturbance (Bregnballe et al., 2009). Other literature shows that cormorant tolerate high levels of activity and the presence of artificial structures, so are less vulnerable to noise and visual disturbance.	Cormorant was not assessed in the Goodship and Furness (2022) paper, however from other literature they are deemed to have low sensitivity. FIDs have been recorded from 7m – 200m to human activity for cormorant, and as such a 300m ZoI for disturbance is considered suitable.
Dunlin (300m ZoI)	During the non-breeding season, minimum and maximum FIDs for dunlin have been recorded from 5m to 450m in response to pedestrians (Collop et al., 2016; Laursen et al., 2005). A mean FID of 52m has been recorded to motorized watercraft, with and a minimum and maximum FID of 9m and 175m respectively (Scarton, 2018).	Goodship and Furness (2022) have assessed dunlin as having a medium sensitivity to disturbance, with a suggested disturbance buffer of 150m-300m during the non-breeding season. Due to the range of FIDs recorded in literature and from personal observations (Andy Douse) noted in Goodship and Furness (2022), a 300m ZoI for disturbance is considered suitable.
Goldeneye (300m ZoI)	During the non-breeding season, FIDs for goldeneye to pedestrians have been shown to be a minimum and maximum of 75m to 150m respectively (Liley et al., 2010), with other records showing a maximum of up to 200m (Hume, 1976). Maximum FIDs to motorized watercraft (jet-ski) have been recorded for goldeneye up to 830m (Laursen et al., 2017), with smaller FIDs to non-motorised watercraft ranging from 300m-400m (Laursen et al., 2017).	Goldeneye have been assessed as having a high sensitivity to disturbance in Goodship and Furness (2022). A buffer zone of 150m-800m is suggested for the non-breeding season. The larger FIDs for goldeneye are based on watercraft, with pedestrian-based disturbance unlikely at a distance over 150m. Therefore, a 300m ZoI is considered suitable for disturbance.
Great crested grebe (300m ZoI)	During the non-breeding season, great-crested grebe FIDs range from 70m for a large land-based vehicle (McLeod et al., 2013) to 340m to non-motorised watercraft (Laursen et al., 2017). In response to pedestrians along the shoreline in England, great crested grebe have shown minimum and maximum FID's of 20m-100m (Liley et al., 2010).	Great crested grebe has been assessed as having medium sensitivity to disturbance in Goodship and Furness (2022), however a non-breeding season buffer is not provided. A 300m ZoI for disturbance is considered suitable for great crested grebe as FIDs range up to 340m.
Grey plover (300m ZoI)	During the non-breeding season, FIDs vary for grey plover, however the maximum recorded is 400m (Laursen et al., 2005). The minimum FID has been recorded as 32m (Mikula et al., 2018) with the majority of FID values in the literature averaging around 150m.	Grey plover has been assessed as having medium sensitivity to disturbance in Goodship and Furness (2022). A 150m-350m buffer zone is suggested during the non-breeding season. A 300m ZoI is considered suitable for grey plover as mean FIDs are under 200m.

Species	Discussion	Zone of Influence (ZoI) Validity
Knot (300m ZoI)	The Waterbird Disturbance Mitigation Toolkit (WDMT) (Cutts et al., 2013) states that knot has high sensitivity to noise disturbance but is tolerant of visual disturbance. It also states that knot will forage within 50m of plant and within 75m of workers. FIDs have been recorded for knot in the non-breeding season at a range of distances, from 21.3m to surveyors walking in Australia (Weston et al., 2012), and a maximum of 240m to surveyors walking a shoreline in England (Collop et al., 2016).	Knot have been assessed as having a medium sensitivity to disturbance in Goodship and Furness (2022). There are a lack of studies regarding FID during the non-breeding season, and so no buffer is suggested. With FIDs recorded up to 240m, a 300m ZoI for knot is deemed suitable for disturbance.
Lapwing (300m ZoI)	Laursen et al. (2005) has shown lapwing as having an escape distance of a minimum of 45m and maximum of 450m. The WDMT (Cutts et al., 2013) states that lapwing show no response to visual disturbance at 300m-400m.	Lapwing has not been assessed in Goodship and Furness (2022). The WDMT has classed lapwing as medium sensitivity to disturbance. The 300m ZoI is deemed suitable for lapwing due to the escape distances recorded and lack of response to visual disturbance at over 300m.
Mallard (300m ZoI)	FIDs for mallard during the non-breeding season have been recorded ranging between 2.8m and 400m to surveyors walking in various habitats (Weston et al., 2012; Laursen et al., 2005).	Mallard has been assessed as having a low to medium level of sensitivity to disturbance in Goodship and Furness (2022). A buffer of ≥100m is suggested during the non-breeding season. Due to the suggested buffer and FIDs recorded, a 300m ZoI for disturbance is considered suitable.
Oystercatcher (300m ZoI)	During the non-breeding season, a range of FIDs for oystercatcher has been recorded, with a maximum FID of 200m recorded for pedestrian activities (Liley et al., 2010) and a mean FID of 137m to surveyors walking over mudflats in Scotland (Dwyer, 2010).	Oystercatcher has been assessed as having a medium sensitivity to disturbance in Goodship and Furness (2022). A buffer of 150m – 300m is suggested during the non-breeding season. Due to FID ranges recorded, the 300m ZoI for disturbance is deemed suitable for oystercatcher.
Red-breasted merganser (300m ZoI)	FID distances for marine traffic show that 90% of red-breasted merganser are flushed at a distance of 250m (Gittings and O'Donoghue, 2016). For pedestrian disturbance, there is evidence that red-breasted mergansers are tolerant between 30m-150m (Goodship and Furness, 2019).	Red-breasted merganser have not been assessed in Goodship and Furness (2022). However, through other literature these have been assessed as a medium sensitivity to disturbance. There is no suggested buffer zone, however FID has been discussed in the previous column. As red-breasted merganser have been shown to be tolerant to land based activities from 30m-150m, a 300m ZoI for disturbance is considered suitable to minimize any FID events.
Redshank (300m ZoI)	During the breeding season, mean FIDs for redshank have been recorded between 19m and 41m, with a maximum FID recorded of 57m (Diaz et al., 2021). During the non-breeding season, multiple FIDs have been recorded in response to surveyors walking along the shoreline and mudflats, ranging from 40m to 450m with the mean FID averaging around 150m (Laursen et al., 2005).	Redshank has been assessed as a medium sensitivity to disturbance in Goodship and Furness (2022). A buffer of 200m-300m has been suggested for the non-breeding season. The 300m ZoI is deemed sufficient for disturbance for redshank due to FIDs recorded.
Ringed plover (300m ZoI)	During the non-breeding season, FIDs for ringed plover have been recorded up to 162m (Smit and Visser, 1993) in response to pedestrians on tidal flats, however FIDs of mixed winter roosts containing ringed plover have been recorded up to 270m (Scarton, 2018).	Ringed plover has been assessed as having a medium sensitivity to disturbance in Goodship and Furness (2022). A buffer of 100m-300m has been suggested for the non-breeding season. The 300m ZoI for disturbance is considered suitable for ringed plover due to FIDs recorded.
Sandwich tern (300m ZoI)	There is a lack of research available however, Goodship and Furness (2022) note that away from breeding grounds, sensitivity is considered to be low.	Goodship and Furness (2022) has assessed Sandwich tern as having a high sensitivity to human disturbance. A 50m buffer has been suggested for the non-breeding season. Therefore, a 300m ZoI for disturbance is considered suitable.
Turnstone (300m ZoI)	Turnstone are an extremely tolerant species to all forms of disturbance, with an FID of 30m-50m. One example of turnstone being flushed at 100m was caused by moving trucks (Cutts et al., 2009; Cutts et al., 2013).	Turnstone have not been assessed by Goodship and Furness (2022), however they have been assessed as having low sensitivity to disturbance.

Species	Discussion	Zone of Influence (ZoI) Validity
		As turnstone are known to be a highly tolerant species, a ZoI of 300m is considered suitable.
650m ZoI for visual disturbance		
Common scoter (650m visual ZoI)	During the non-breeding season when common scoter are in flocks on water, they have been observed to have median FID of 804m and a maximum FID of 3200m from large commercial ships in Germany (Schwemmer et al., 2011), and a maximum FID of 100m to a high-speed ferry service in Denmark. A buffer zone for forestry operations in the UK ranges from 300m – 800m during the breeding season, and personal observations (by Griffin, L.) referenced in Goodship and Furness (2022) show that common scoter keep a minimum distance of 300m from boats and pedestrians.	Common scoter have been assessed to have a high sensitivity to human disturbance, with Goodship and Furness (2022) suggesting a buffer zone of 300m-500m. During the non-breeding surveys undertaken for the Scheme, common scoter were not recorded within the ZoI, and there are only 7 individual records of common scoter within the wider study area recorded during these surveys. This species are likely to be absent from the ZoI during construction of the Scheme. Therefore, a 650m visual ZoI for disturbance is appropriate for common scoter.
Curlew (650m visual ZoI)	During the non-breeding season, surveyors walking over mudflats in Scotland caused a mean FID of 235.16m (Dwyer, 2010) for curlew, with other mean FIDs recorded as 88m (Brett, 2012) to surveyors walking in an estuary, and a mean minimum/maximum of 88m to 570m (Collop et al., 2016) to surveyors walking a shoreline in England. An FID has been recorded up to 650m for curlew from surveyors walking along mudflats, with the mean FID from this range 298m (Laursen et al., 2005). Agricultural activities and motorised vehicles caused a mean FID of 129m and 188m respectively (Smit and Visser, 1993), as well as a 200m Minimal Approach Distance (MAD)[1] to pedestrians running along footpaths close to intertidal areas in England (Burton et al., 2002)	Curlew have been assessed to have a high sensitivity to human disturbance, with Goodship and Furness (2022) suggesting a non-breeding season buffer of 200m-650m. Mean FID for curlew ranges between less than 200m and up to 650m. Therefore, a 650m visual ZoI for disturbance for this species is considered suitable.
Eider (650m visual ZoI)	There is limited research available for eider, however the available literature identifies that during the non-breeding season FIDs range from 0m to 3200m in response to large commercial fishing ships, with a median FID of 208m (Schwemmer et al., 2011). Maximum alert distances to surveyors in a motorboat approaching moulting eiders were recorded at 600m, and for smaller motorized watercraft, FIDs range from 30m-400m (Dehnhard et al., 2020).	Eider have been assessed as having a medium/high sensitivity to disturbance in Goodship and Furness (2022), with a suggested buffer of 200m-500m during the non-breeding season. Some FIDs range up to 400m. A maximum FID of 3200m was recorded to a large commercial fishing vessel. Large vessels regularly travel to and from the Port of Grangemouth, therefore any eider present is likely to be habituated to the presence of large boats. A peak count of only five eider has been recorded during surveys for the Scheme, with eider recorded on four occasions in total (two counts of two birds, one count of three birds, and one count of five birds). As they are likely to be absent from the area during works, a 650m visual ZoI for disturbance is considered suitable for eider for this Scheme.
Golden plover (650m visual ZoI)	During the non-breeding season, FIDs for golden plover have been recorded as a minimum of 45m and maximum of 450m (Laursen et al., 2005), with mean FIDs recorded as 143m in response to surveyors walking in mudflats in Denmark (Laursen et al., 2005) and 280m to surveyors walking over mudflats in Scotland (Dwyer, 2010).	Golden plover is assessed to have a medium sensitivity to human disturbance in Goodship and Furness (2022). A 200m-500m buffer zone is suggested. A 650m visual ZoI is considered suitable for disturbance to golden plover. Mean FIDs range from 140m to 280m, with a maximum of 450m. Therefore, a 650m ZoI is considered suitable.
Pink-footed goose (650m visual ZoI)	There is limited research on pink-footed goose FID during the non-breeding season. During the migratory season, a range of mean FID decreased from 500m to 350m after the closure of the hunting season.	Pink footed goose is assessed as having a high sensitivity to human disturbance in Goodship and Furness (2022). A buffer zone of 500m – 1000m is suggested for the non-breeding season.

Species	Discussion	Zone of Influence (ZoI) Validity
	During the non-breeding season, a minimum and maximum FID has been recorded as 350m and 500m respectively (Fox and Madsen, 1997).	However, there is evidence of pink-footed goose being tolerant of disturbance at shorter distances, with disturbance distances in the closed hunting season being as low as 350m. Most pink-footed goose records from the 2022/23 surveys for the Scheme are in the vicinity of Bothkennar Pools and along the shoreline immediately north-east of these pools. Similarly, the 2015/16 and 2016/17 surveys recorded pink-footed goose in this area and in close proximity to Kincardine Bridge. This area around Bothkennar Pools is largely screened from the construction areas due to the surrounding embankments. Therefore, it is considered that most individuals present in the wider area will not be disturbed, and the 650m ZoI is considered suitable to minimize any FID events.
Red-throated diver (650m visual ZoI)	During the non-breeding season, mean FIDs for red-throated diver have been recorded as 1200m to motorized watercraft, and 1400m to non-motorised watercraft (Laursen et al., 2017).	Red-throated diver has been assessed as having a high sensitivity to disturbance. A buffer of ≤1000m during the non-breeding season is recommended (Goodship and Furness 2022). This recommendation is related to disturbance by shipping vessels and watercraft. Red-throated diver have been shown to be more tolerant of some boats (Jarrett et al., 2018). Construction activities will occur at the estuary edge and red-throated diver are unlikely to be present here as they primarily forage in deeper water further offshore and roost only on water. Based on this and published FIDs, a 650m ZoI for disturbance is considered suitable to minimize any FID events.
Scaup (650m visual ZoI)	There are limited studies on FID for scaup, with FIDs only available for non-breeding season. Pochard and tufted duck have been used as proxies for scaup, with FIDs recorded as 10m to 30m for these species (Diaz et al., 2021). During the non-breeding season, the mean MAD has been recorded as 146m (Trulio and White, 2017) in response to pedestrians, and 450m to watercraft (Havera et al., 1992).	Goodship and Furness (2022) has assessed scaup as having a high sensitivity to human disturbance. A buffer zone of 150m-450m has been suggested for the non-breeding season. A 650m visual ZoI is considered suitable for disturbance to scaup due to FID's recorded.
Shelduck (650m visual ZoI)	FID for shelduck during the non-breeding season have been recorded as a mean of 178.4m in response to surveyors walking over mudflats in Scotland (Dwyer, 2010) and 36m to surveyors walking in Europe (Møller and Erritzøe, 2010), with a max of 700m recorded to surveyors walking over mudflats in Denmark in Laursen et al. (2005).	Shelduck has been assessed as having a high sensitivity to disturbance in Goodship and Furness (2022). A buffer zone of 100m-400m has been suggested for the non-breeding season. As the suggested buffer from the literature is 150m-400m for shelduck, a 650m visual ZoI for disturbance is therefore considered suitable.
Wigeon (650m visual ZoI)	FIDs for wigeon during the non-breeding season in response to pedestrians range from 20m to 1000m (Liley et al., 2010), with a majority of records showing FIDs at 200m to 300m (Goodship and Furness, 2022). FIDs are larger in response to watercraft and may be up to 500m (Laursen et al., 2017).	Wigeon has been assessed as having a high sensitivity to human disturbance in Goodship and Furness (2022). A buffer zone of 200m-500m has been suggested for the non-breeding season. Due to the FIDs recorded for wigeon, a 650m ZoI for disturbance is considered sufficient.

[1] Terms used within the table are sourced from the literature referenced. These terms have been kept as per the original source of the research. Terms may change per species, however for the purposes of this document these terms are interchangeable: Flight Initiation Distance (FID), Minimum Approach Distance (MAD), Alert Distance and Escape Distance

The information provided in Table 4.1 identifies that the strategic level approach of a 300m noise and visual ZoI suggested by Cutts et al. (2013) is suitable for most qualifying species of the Firth of Forth SPA/Ramsar site and Loch Leven SPA/Ramsar site for the purposes of this HRA. The available literature indicates that nine species (common scoter, curlew, eider, golden plover, pink-footed goose, red-throated diver, scaup, shelduck, and wigeon) have visual disturbance/response thresholds at distances greater than 300m from the source of disturbance. To

avoid implementing several ZoI, for the purposes of this assessment, the recommended visual disturbance buffer of the most sensitive species (650m for curlew) has been applied to all species with a visual disturbance threshold of more than 300m. Therefore, the 650m ZoI is very precautionary for some of the nine species (e.g. eider and scaup) based on a review of the literature.

The 300m ZoI and 650m visual ZoI for selected species from the edge of the construction Site Boundary is shown on Figure 10.

4.3.3 Consultation

Consultation was undertaken with a number of statutory and non-governmental organisations to gain advice on the surveys required to inform the AA and to investigate historical records of the numbers and distribution of qualifying species in the Firth of Forth to provide context to the gathered survey data. Consultees included:

- NatureScot;
- the Royal Society for the Protection of Birds (RSPB); and
- the British Trust for Ornithology (BTO) (requests for Wetland Bird Survey (WeBS) data).

4.3.4 Desk Study

A desk study was undertaken to gather relevant baseline information on the qualifying interests of the Firth of Forth SPA/Ramsar site, including cormorant, who are known to travel to the Firth of Forth from Loch Leven SPA/Ramsar site. All relevant data was collated from various up to date, recognised sources and published material relating to the qualifying species and reviewed in relation to the Scheme. Sources included:

- information on the qualifying species including details on ecology, distribution, population size, trends, pressures and threats, ranging from an international overview down to a national, Scottish and site-specific scale (Appendix B Ornithological Information);
- the international, national (UK and Scottish) conservation status of qualifying species, based on the most recent site condition monitoring reports from NatureScot;
- recent population estimates of qualifying species within the SPA based on WeBS data; and
- published information on the migration of waterbirds through the Firth of Forth.

The most recently available BTO WeBS data were obtained for the latest five-year period (2016/17, 2017/18, 2018/19, 2019/20 and 2020/21). Data received covered the non-breeding period (from September to March inclusive). WeBS data from the 'Forth Grangemouth to Kincardine Bridge' and 'Grangepans to Grangemouth' BTO WeBS count sectors (Figure 10) were compared with the project's survey data for Sectors 4, 6, 7, 8, 9, 10 and 11 in order to ascertain if the two years' worth of data collected for the Scheme was representative of the longer term (five years) WeBS dataset. Project survey Sector 5 is not covered by either WeBS count sector (Figure 10) and was therefore not included in the comparison.

Methods of data collection differed between the WeBS surveys and the bird surveys carried out for the Scheme, therefore the two datasets are not directly comparable in terms of estimating population sizes. Data were compared to inspect for similarities or anomalies with respect to species diversity, patterns of rises and falls in bird numbers by month, and approximate locations of aggregations of birds. The WeBS data received are presented in Appendix B (Ornithological Information).

4.3.5 Bird Surveys

Ornithological surveys were undertaken over the winters of 2015/2016, 2016/2017 and 2022/2023 to assess the usage of the Firth of Forth area by non-breeding birds, including those species listed as qualifying species of the Firth of Forth SPA/Ramsar site. Cormorant are considered to be the only qualifying species of the Loch Leven SPA/Ramsar site affected by the Scheme as they are known to travel to the Firth of Forth. As cormorant are also a qualifying species of the Firth of Forth SPA, and it is their presence in the Firth of Forth that could be impacted,

the analysis of the survey data will be against the Firth of Forth SPA population. The survey method was agreed with NatureScot prior to commencement and is detailed in the Grangemouth Flood Alleviation Scheme: Ornithology Survey Desk Study and Proposed Scope (CH2M Hill, 2015). The aim of the surveys was to establish the ornithological baseline (abundance and distribution of bird species through the tidal cycle in the study area, during the study period) to allow an assessment of potential effects of the Scheme on ornithological features, particularly the SPA qualifying species. The surveys in 2015/16 and 2016/17 covered a distance of approximately 26km along the southern shore of the Firth of Forth, which was divided up into 16 Sectors. Surveys were conducted in 2022/2023 over an 11km distance of the shore within Sectors 4-11 due to a refinement of the Scheme design and followed the same method as the previous surveys. Data collected and survey methodology used is summarised in Appendix B (Ornithological Information).

4.3.6 Analysis of the Scheme's Survey Data

Survey data from the bird surveys conducted for the Scheme were used to inform the assessments of the potential effects of habitat loss and bird disturbance. A subset of the data was used, namely data from within count Sectors 4-11, which coincide with the locations of the proposed works, to present information on abundance and distribution of birds within the study area. For each qualifying species recorded within each survey sector in the study area, the peak count of each tidal state during each survey was used to determine distribution and abundance of birds within each sector. From this dataset, a further subset of data, i.e. records from within the ZoI was then used to inform the assessment. The methods of analysis highlight particular locations within the study area and ZoI which host important numbers of qualifying species within the context of the SPA, for example the presence of high tide roosts. Heat density maps (see Section 4.3.9) of data within Sectors 4-11 were used to inform the ZoI assessments and also provide context of bird numbers within the wider survey areas.

Peak counts for each species at rising/high tide were calculated as percentages to help highlight species which occur in large numbers relative to the population size noted in the SPA citation and of the Forth estuary 5-year average (2017/18 to 2021/22) (Frost et al., 2023), and are presented below in Table 4.2 and Table 4.3 for the study area, and for the ZoI respectively.

4.3.7 Bird Survey Results

4.3.7.1 Species within the Study Area

A total of 24 qualifying species (out of a total of 27 species) were recorded within the study area (Sectors 4-11) during the surveys. Common scoter was recorded in the study area, but not within the ZoI. The three species that were not recorded within the study area are: Slavonian grebe, long-tailed duck and velvet scoter. Slavonian grebe was recorded in Sectors 13-15, which is outwith the study area (Sectors 4 – 11). Long-tailed duck and velvet scoter were absent from all survey sectors (Sectors 1-16).

Table 4.2 details the peak species count recorded within the study area. These numbers are also provided as percentages of the cited SPA population to help highlight species present in larger proportions of the SPA population as recorded at classification. The 5-year average population of the estuary from the 2017/18 to 2021/22 winters (Frost et al., 2023) is also provided.

Table 4.2 Peak species counts at rising/high tide within the study area as percentages of the Firth of Forth SPA population at classification and of the five-year average population of the estuary from the 2017/18 to 2021/22 winters. Species are ordered by percentage of cited SPA population.

Species	Peak Study Area Count	Cited SPA Population[1]	% of Cited SPA Population	Forth Estuary 5-year Average[2]	% of 5-year Average
Dunlin	11000	9514	115.6%	5833	188.6%
Shelduck	4700	4509	104.2%	3952	118.9%
Knot	7300	9258	78.9%	3510	208.0%
Ringed plover	210	328	64.0%	419	50.1%

Species	Peak Study Area Count	Cited SPA Population[1]	% of Cited SPA Population	Forth Estuary 5-year Average[2]	% of 5-year Average
Redshank	1470	4341	33.9%	4704	31.3%
Bar-tailed godwit	630	1974	31.9%	996	63.3%
Wigeon	660	2139	30.9%	2648	24.9%
Curlew	490	1928	25.4%	3040	16.1%
Red-breasted merganser	130	670	19.4%	297	43.8%
Lapwing	750	4148	18.1%	2757	27.2%
Cormorant	110	682	16.1%	575	19.1%
Golden plover	436	2949	14.8%	1174	37.1%
Pink-footed goose	1370	10852	12.6%	18635	7.4%
Oystercatcher	590	7846	7.5%	6929	8.5%
Grey plover	52	724	7.2%	178	29.2%
Mallard	180	2564	7.0%	1094	16.5%
Scaup	28	437	6.4%	24	116.7%
Great crested grebe	30	720	4.2%	96	31.3%
Red-throated diver	2	90	2.2%	56	3.6%
Turnstone	12	860	1.4%	721	1.7%
Sandwich tern	17	1617	1.1%	1973	0.9%
Goldeneye	23	3004	0.8%	1237	1.9%
Eider	22	9400	0.2%	4620	0.5%
Common scoter	1	2880	0.03%	2781	0.04%

[1]Population estimates are taken from JNCC (2001) and are for the years 1993/94-1997/98 for species that qualify under Article 4.1 and 1992/93-1996/97 for those species that qualify under Article 4.2

[2]Five year average population for the Forth estuary is taken from the 2017/18-2021/22 winters as detailed in Waterbirds in the UK 2021/22: The Wetland Bird survey and Goose & Swan Monitoring Programme (Frost et al., 2023)

Cormorant is also a qualifying species of Loch Leven SPA, which has a cited Loch Leven SPA population of 391 individuals and a Forth Estuary 5-year average of 575. Following the same approach as above, the peak study area count (110) for cormorant accounts for 28.1% of the cited Loch Leven SPA population.

4.3.8 Species within the ZoI for Noise and Visual Disturbances

Twenty-three species recorded within the study area were also recorded in the ZoI for noise and visual disturbances, and one species was absent from the ZoI entirely (common scoter) (Table 4.3).

Table 4.3: Peak species counts within the ZoI for disturbance as percentages of the Firth of Forth SPA population at classification and of the five-year average population of the estuary from the 2017/18-2021/22 winters. Species are ordered by percentage of cited SPA population.

Species	Peak ZoI Count	Cited SPA Population[1]	% of Cited SPA Population	Forth Estuary 5-year Average[2]	% of 5-year Average
Dunlin	11000	9514	115.6%	5833	188.6%
Knot	7300	9258	78.9%	3510	208.0%
Ringed plover	210	328	64.0%	419	50.1%
Redshank	1470	4341	33.9%	4704	31.3%
Bar-tailed godwit	630	1974	31.9%	996	63.3%

Species	Peak ZoI Count	Cited SPA Population[1]	% of Cited SPA Population	Forth Estuary 5-year Average[2]	% of 5-year Average
Shelduck (650m ZoI)	1440	4509	31.9%	3952	36.4%
Wigeon (650m ZoI)	660	2139	30.9%	2648	24.9%
Curlew (650m ZoI)	430	1928	22.3%	3040	14.1%
Golden plover (650m ZoI)	436	2949	14.8%	1174	37.1%
Lapwing	548	4148	13.2%	2757	19.9%
Pink-footed goose (650m ZoI)	1370	10852	12.6%	18635	7.3%
Cormorant	60	682	8.8%	575	10.4%
Oystercatcher	588	7846	7.5%	6929	8.5%
Mallard	180	2564	7.0%	1094	16.5%
Red-breasted merganser	28	670	4.2%	297	9.4%
Scaup (650m ZoI)	17	437	3.8%	24	70.8%
Red-throated diver (650m ZoI)	2	90	2.2%	56	3.6%
Great crested grebe	11	720	1.5%	96	11.5%
Grey plover	7	724	1.0%	178	3.9%
Goldeneye	23	3004	0.8%	1237	1.9%
Sandwich tern	11	1617	0.7%	1973	0.6%
Turnstone	4	860	0.5%	721	0.6%
Eider (650m ZoI)	5	9400	0.02%	4620	0.02%

[1]Population estimates are taken from JNCC (2001) and are for the years 1993/94-1997/98 for species that qualify under Article 4.1 and 1992/93-1996/97 for those species that qualify under Article 4.2

[2] Five year average population for the Forth estuary is taken from the 2017/18-2021/22 winters as detailed in Waterbirds in the UK 2021/22: The Wetland Bird survey and Goose & Swan Monitoring Programme (Frost et al., 2023)

Cormorant is also a qualifying species of Loch Leven SPA, which has a cited Loch Leven SPA population of 391 individuals and a Forth Estuary 5-year average of 575. Following the same approach as above, the peak ZoI area count (60) for cormorant accounts for 15.3% of the cited Loch Leven SPA population.

Although the peak shelduck count for high and rising tides within the ZoI is 1440 birds, a large flock (4,700 birds) was recorded at low tide within the ZoI, north of the River Avon. A moulting flock of shelduck is known to be present in the Firth of Forth close to this location (Bryant, 1978; Green et al., 2019). During the moulting period, shelduck are completely flightless and so are more vulnerable to disturbance and predation (Salomonsen, 1968). Extensive mudflat areas offer good protection from predation and human disturbance, whilst providing abundant food resources. Given the size of this flock and the likelihood that they occupy a larger area than the point data suggests, on a precautionary basis, moulting shelduck has been considered in the assessment.

4.3.9 Heat Density Mapping

Heat density maps have been produced for the qualifying species whose peak counts recorded within the ZoI resulted in the 12 highest percentages of the cited SPA population. For context, all data within Sectors 4-11 has been included, not data just within the ZoI. These maps show the location of hotspots for foraging at low tide, roosting at high tide and within which months aggregations occur. User instructions and further information about the heat density maps can be found in Appendix B (Ornithological Information). All other species recorded either infrequently or in low aggregations are shown in Figures 22-32.

4.3.10 Key Points from Bird Survey Results

24 of 27 qualifying species were recorded within the survey study area, twenty-three of which were recorded within the ZoI. Common scoter is the only qualifying species that was recorded within the study area, but not within the ZoI. Long-tailed duck, Slavonian grebe and velvet scoter were absent from the study area. Details of species recorded during surveys can be found in Appendix B (Ornithological Information). The bird surveys recorded the largest numbers of roosting waders between December and March, with particularly high numbers in January 2017 in survey Sectors 9 and 10.

The recorded distribution of birds was relatively consistent throughout the survey period. Particularly large aggregations were recorded roosting at the below locations, which are identified on Figure 10:

- the sheltered bay adjacent to petrochemical plant in Sector 9, more than 50m from the Scheme at its nearest point;
- the breakwater adjacent to the Port of Grangemouth in Sector 6, more than 50m from the Scheme at its nearest point;
- mudflats and creeks at the mouth of the River Avon in Sector 10, adjacent to Scheme; and
- Bothkennar Pools, north of the River Carron in Sector 5, more than 300m from the Scheme at its nearest point.

Sector 9 supported some of the largest peak counts of bar-tailed godwit, curlew, golden plover, dunlin, knot, ringed plover and shelduck. This sector provides important feeding habitat and roosting habitat for a number of species within the SPA. The surveys undertaken in 2016/17 and 2022/23 showed that Sector 9 is particularly important as a roosting area for waders and bar-tailed godwit, curlew, golden plover, knot, lapwing, redshank, shelduck and dunlin roosted in the sheltered bay area in the western part of the sector. This area was found to be largely undisturbed by humans during field surveys, mainly because public access is restricted by the presence of the petrochemical plant.

The breakwater was found to support large numbers of roosting and feeding birds, in particular redshank, dunlin, lapwing, curlew and oystercatcher. Peak counts of these species often occur just before high tide, as large high tides limit the amount of roosting habitat available within the estuary.

From the comparison of WeBS and the Scheme's datasets, the survey data collected for the Scheme was seen to correlate well with the WeBS data collected over a longer period of time, indicating the survey data is representative of ongoing bird use of the habitats in the study area. However, several species counts in the survey data were notably higher than their corresponding WeBS count for that month (e.g. redshank and dunlin). This indicates that bird use of the estuary can vary within a given month, and possibly within the space of a few days, depending on the dates the WeBS count and surveys for the Scheme were undertaken.

4.4 Bird Monitoring During Ground Investigation Works

4.4.1 Introduction

To inform the design and construction of the Scheme, numerous phases of Ground Investigation (GI) works have been conducted. Phase 5 was conducted around the perimeter of the Port of Grangemouth and works were undertaken at 35 locations comprising trial pits (TP), boreholes (BH) and cone penetration testing (CPT) (Figure 11). Bird monitoring surveys were undertaken during these GI works to gather data on the birds' reaction to works.

4.4.2 Methods

Monitoring during GI works was undertaken by two competent ecologists between August 2019 and January 2020 to account for differing use of the site by birds through the period and during all tidal states (high, mid and low). Monitoring was undertaken during a range of ground investigation types: cable percussive drilling at boreholes; rotary drilling at boreholes, and cone penetration tests, and at locations both adjacent to and more distant from

the SPA boundary. Bird monitoring took place at ten GI locations; eight boreholes and two CPT locations (Table 4.4).

Survey duration varied depending on GI activity, but each survey typically lasted three hours. Where possible, ecologists began the monitoring period prior to the commencement of the GI works and continued to monitor for a period after GI activity ceased. Ecologists observed birds for the duration of the survey period using binoculars and a telescope. Weather conditions during each monitoring period are detailed in Appendix B (Ornithological Information). At the beginning of the survey and again each hour, birds within a 300m ZoI from the GI position (see Section 4.3.2) were plotted onto a basemap using standard BTO species codes to provide an hourly snapshot of bird distribution. Birds were assigned a behaviour code of either feeding, loafing or roosting.

In addition to mapping birds each hour, Potential Disturbance Events (PDE) were captured on a recording form. The type/category of potential disturbance was categorised as follows, and a description was recorded in the field:

- Anthropogenic (GI-related) (e.g. noise from drilling rig, visual disturbance from contractors).
- Anthropogenic (non GI-related) (e.g. industrial activity, aircraft, boat).
- Predator/threat species (e.g. raptor, fox).
- Non predator/threat species (e.g. cormorant).
- Unknown (i.e. the source of the disturbance was unknown and therefore not recordable by observers).

Reaction types were categorised as follows, and a description was recorded in the field:

- Fly up (birds fly up and either return to same location or leave the area).
- Attack (birds fly towards disturbance and mob it).
- On-ground agitation (birds become alert / unsettled but do not fly).
- No observable reaction.

Reactions to PDEs at any distance were recorded, not just within the 300m ZoI, if observed by the ecologists.

4.4.3 Results

Five of the ten locations were predicted to have LSE as identified in the HRA for GI works (Jacobs, 2019). GI related anthropogenic PDEs were observed on 88 occasions; birds reacted to only five of these events (Table 4.4). No LSE were identified for BHFP11, which was visually screened from the SPA, however redshank reacted twice during the nine GI-related disturbance events. Ten redshank appeared to be agitated on the ground during low tide, but did not disperse as a result of the disturbance on one occasion, and seven redshank flew approximately 30m along the breakwater, away from the disturbance, on the second occasion.

Table 4.4: Disturbance events recorded during bird monitoring of GI works.

GI Location	LSE identified in GI HRA	Date and Time	Tide	PDE Types	Qualifying Species within 300m (Peak Count)*	Reactions
BHFP04	New location. No LSE predicted as borehole was 135m from SPA and naturally screened.	24 September 2019, 08:10-09:40	Mid	4 x Anthropogenic (GI related)	Cormorant (1) and mallard (4) at mouth of River Carron.	None
BHFP07	LSE identified in GI HRA. Borehole was 8m from SPA, on the road verge immediately	11 December 2019, 10:10-12:00	Mid	2 x Anthropogenic (GI related)	Wigeon (2), curlew (2), cormorant (2) and shelduck (4) feeding and loafing mainly on or behind breakwater.	None

GI Location	LSE identified in GI HRA	Date and Time	Tide	PDE Types	Qualifying Species within 300m (Peak Count)*	Reactions
	adjacent to the sites with no natural screening.				Approximately 100 redshank and 20 dunlin roosting in western channel in centre of port (not in estuary).	
BHFP08	LSE identified in GI HRA. Borehole was 6m from SPA, on the road verge immediately adjacent to the sites with no natural screening.	22 October 2019, 08:15-12:25	High	7 x Anthropogenic (GI related)	Curlew (13), redshank (228), dunlin (111), grey plover (1) and shelduck (11) foraging behind breakwater. Redshank (323), dunlin (34) and cormorant (2) loafing and roosting on/in front of breakwater. Redshank (237) roosting at estuary edge.	One fly up: Redshank and dunlin (60 individuals) on the south side of the breakwater flew approximately 25m to the north side of the breakwater.
				1 x Anthropogenic (Non-GI related)		None
				1 x Predator / threat		Fly up: Carrion crows flushed 240 redshank (not entire flock) which flew out of sight.
				1 x Unknown		All waders (except curlew) (450 individuals) flew approximately 500m downstream and roosted on the breakwater.
		31 October 2019, 09:15-11:40	Low	3 x Anthropogenic (GI related)	Curlew (5), lapwing (130), redshank (47) and shelduck (25) foraging and loafing behind breakwater. Redshank (165), bar-tailed godwit (4) and lapwing (61) roosting on breakwater.	None
BHFP09	No LSE identified in GI HRA. Borehole was 17m from SPA, immediately adjacent to the port infrastructure and naturally screened from the sites.	23 September 2019, 09:45-13:15	High	7 x Anthropogenic (GI related)	Shelduck (17), lapwing (1), oystercatcher (1) and curlew (5) foraging and loafing behind breakwater. Redshank (266), dunlin (7), shelduck (3) ringed plover (1), curlew (1) and oystercatcher (2) roosting, foraging and loafing on River Carron mudflats on southern side of breakwater.	None
				1 x Anthropogenic (Non-GI related)		One fly up: Redshank (30 individuals) flew out of sight.
BHFP10	LSE identified in GI HRA. Borehole was 4m from SPA, on the road verge immediately adjacent to the sites with no natural screening.	11 October 2019, 09:00-10:45	Low	5 x Anthropogenic (GI related)	Shelduck (3) and curlew (1) foraging behind breakwater. Mallard (4) loafing in River Carron. Curlew (1) roosting on breakwater. Curlew (1) foraging at estuary edge.	None
				1 x Anthropogenic (Non-GI related)		Fly up: Wildfowling approximately 2km to the northeast. Pink-footed goose (50 individuals) flew over survey location from that direction, heading southwest.

GI Location	LSE identified in GI HRA	Date and Time	Tide	PDE Types	Qualifying Species within 300m (Peak Count)*	Reactions
		15 October 2019, 09:15-11:15	Low	7 x Anthropogenic (GI related)	Shelduck (9), curlew (7) and redshank (211) foraging behind breakwater. Curlew (1) loafing on breakwater. Curlew (3), mallard (17), cormorant (1), oystercatcher (1) and redshank (101) loafing and foraging in mudflats in front of breakwater.	None
BHFP11	No LSE identified in GI HRA. Borehole was 14m from SPA, immediately adjacent to the port infrastructure and naturally screened from the sites.	11 September 2019, 08:15-10:00	Low	3 x Anthropogenic (GI related)	Shelduck (15), curlew (9), oystercatcher (1), foraging and roosting behind and near breakwater. Redshank (44) foraging and loafing on mudflats in front of breakwater and on edge of River Carron. Curlew (1) foraging at estuary edge.	One on ground agitation: In response to the noise of machinery starting, redshank (10 individuals) became alert and slightly agitated but did not fly.
		19 September 2019, 08:30-10:00	Mid	6 x Anthropogenic (GI related)	Shelduck (19), curlew (10), oystercatcher (8) and redshank (74) foraging behind breakwater. Curlew (1) and redshank (1) foraging on mudflats in front of breakwater. Curlew (1) and redshank (2) foraging at estuary edge.	One fly up: In response to a loud noise caused by the borehole casing being dropped, redshank (7 individuals) flew approximately 30m away from disturbance along the breakwater,
BHFP12	No LSE identified in GI HRA. Borehole was 16m from SPA, immediately adjacent to the port infrastructure and naturally screened from the sites.	22 August 2019, 08:10-12:14	High	8 x Anthropogenic (GI related)	Shelduck (291) and curlew (3) foraging and loafing behind breakwater. Cormorant (15), shelduck (18) and redshank (39) loafing in front of breakwater. Shelduck (16), dunlin (3) and redshank (140) roosting on and in front of breakwater. Curlew (1) foraging at estuary edge.	None
				1 x Anthropogenic (Non-GI related)		Fly up: Redshank (39 individuals) flew approximately 50m away from disturbance and along the breakwater.
		05 September 2019, 08:30-13:00	High-Low	5 x Anthropogenic (GI related)	Curlew (23), oystercatcher (5), knot (2), redshank (5) and shelduck (15) foraging behind breakwater. Cormorant (14)., curlew (3) and oystercatcher (1) roosting and loafing along breakwater.	None
				1 x Anthropogenic (Non-GI related)		None

GI Location	LSE identified in GI HRA	Date and Time	Tide	PDE Types	Qualifying Species within 300m (Peak Count)*	Reactions
					Redshank (35) and curlew (1) foraging along breakwater. Curlew (1) and redshank (3) foraging at estuary edge.	
BHFP15	LSE identified in GI HRA. Borehole was 11m from SPA at the Port Locks with no natural screening.	05 August 2019, 10:50-12:50 and 14:00-16:05	Low	11 x Anthropogenic (GI related)	Shelduck (310), curlew (8) and redshank (125) foraging in mudflats. Shelduck (940) loafing in mudflats. Shelduck (4 roosting along pier.	One on ground agitation: Shelduck (30 individuals) walked approximately 20m further away from disturbance but did not fly, possibly due to moulting. This was the first day of GI works and the first location to be drilled. The birds did not react after this initial reaction.
		08 August 2019, 08:45-12:15	High	8 x Anthropogenic (GI related)	Redshank (1) roosting at estuary edge. Sandwich tern (5) flying over. Cormorant (5) loafing and roosting along pier. Shelduck (930) roosting and loafing in mudflats. Redshank (87), curlew (2) and shelduck (12) foraging in mudflats.	One fly up: Redshank (8 individuals) flew approximately 30m further away from disturbance
				1 x Non-predator / threat		None
		14 August 2019, 08:00-10:00	Low	1 x Anthropogenic (GI related)	Shelduck (72) loafing in mudflats. Curlew (3), shelduck (3) and oystercatcher (1) foraging in mudflats.	None
				2 x Anthropogenic (Non-GI related)		None
		23 August 2019, 08:00-10:05	High	6 x Anthropogenic (GI related)	Cormorant (18) loafing along pier.	None
CPTFP05	No LSE identified in GI HRA. CPT was 20m from SPA, immediately adjacent to the port infrastructure and naturally screened from the sites.	01 October 2019, 08:45-11:15	Low	3 x Anthropogenic (Non-GI related)	Shelduck (23), redshank (108) and curlew (11) foraging behind breakwater. Redshank (145) and dunlin (1) foraging in front of breakwater. Redshank (90) foraging in mudflats at estuary edge. Redshank (130) roosting at estuary edge.	None – GI location is on the landward side of the road and surrounded by vegetation.
CPTFP11	LSE identified in GI HRA. CPT was 14m from SPA adjacent to Grange Burn with no natural screening.	08 January 2020, 08:30-11:30	Low	5 x Anthropogenic (GI related)	Redshank (284) and dunlin (4) foraging in mudflats along Grange Burn. Mallard (2) roosting in derelict ground within the port.	None
				4 x Anthropogenic (Non-GI related)		None

*peak count for each behaviour over the monitoring period

4.4.4 Discussion

GI-related PDE were observed on 88 occasions during 17 periods of monitoring. No visual/noise barriers were deployed during GI works. On only five occasions was an observable reaction recorded. On three occasions, birds (redshank on all occasions and dunlin on one occasion) flew a maximum of 30m away from the disturbance. Redshank showed on-ground agitation once during GI works, as did shelduck, but there is a possibility that this was a moulting flock of shelduck that were unable to fly. Although the GI works are not directly comparable to the main works for the Scheme, for example in scale and duration, these reactions provide some evidence to suggest that if disturbed by unscreened works (additional noise and increased visual disturbance from site personnel and plant/vehicles), qualifying species may disperse perhaps only a short distance, within the Firth of Forth SPA and Ramsar site, if at all.

4.5 Noise Assessment

4.5.1 Introduction

Grangemouth is a busy industrial area; the Port of Grangemouth is Scotland's largest container port, handling nine million tonnes of cargo through the dock every year (Forth Ports Group, 2023). The port operates 24 hours a day. There are periodic alarm tests carried out at both the port and the petrochemical plant as part of their health and safety and incident response training. Forth Ports have confirmed that they have no noise measurements from within the port.

Immediately to the southeast of the port is the petrochemical site. Within the petrochemical site, there are multiple flares which are regularly used. The frequency and duration of flaring is highly dependent on the flow of oil and gas from the North Sea pipeline and the production at the site.

During a site meeting with NatureScot representatives on 06 June 2019, it was agreed that baseline noise measurements along the estuary edge impacted by works would be beneficial to help contextualise the construction noise in the environment. Noise monitoring was undertaken to determine the baseline noise experienced by birds and record their reactions to the noise emitted from the various tasks and activities undertaken around the port and petrochemical plant.

4.5.2 Methods

4.5.2.1 Site Monitoring

Baseline noise measurements were taken at four locations between 29 and 31 October 2019 (Figure 12). These four locations were selected to provide measurements from across the sites and are located at the edge of the estuary at areas used frequently by birds (MacArthur Green, 2017). Monitoring was undertaken during daylight hours and lasted for approximately two hours at each location. It is important to note that any baseline noise monitoring is a snapshot of the acoustic environment.

Measurements were undertaken using a Castle Mirus Sound Level Meter Set (Serial Number 35769) with a Svantek SV18 Pre-amplifier (Serial Number 41663) and a Svantek 7052E ½" Microphone (Serial Number 58860), calibrated using a Castle GA607 Calibrator (Serial Number 035748).

The equipment complies with the Specification for sound level meters (British Standards Institution, 1994) and capable of operating as a Type 1 integrating sound level meter, complying with the British Standard, Integrating-averaging sound level meters (British Standards Institution, 2001). The meter and calibrator were also calibrated in a National Physical Laboratory (NPL) accredited laboratory. Details of the equipment and calibration are in Table 4.5.

Table 4.5: Measurement Equipment & Calibration Record

Equipment	Serial Number	NPL Calibration Certificate No.	NPL Calibration Certificate Reference	Date
Castle Mirus Sound Level Meter	35769	035748/75944	CDK1806682	30 August 2019
Svantek SV18 Pre-amplifier	41663			
Svantek 7052E ½" Microphone	58860			
Castle GA607 Acoustic Calibrator	035748			

The Sound Level Meter was calibrated before and after the measurements; no significant drift in calibration level was found to have occurred and measurements were considered to be accurate.

Seven measurement parameters were utilised: L_{A10}, L_{A50}, L_{A90}, L_{AMax}, L_{AMin}, L_{Aeq} and L_{APeak}. Variable background noise levels are measured as the noise level which is exceeded for a proportion of the time over a given measurement period. Therefore, L_{A10}, L_{A50} and L_{A90} are the sound levels exceeded for 10%, 50% and 90% respectively of a specified time period. In each case, the suffix 'L_A' implies that the sound pressure level (L) has been A-weighted. The A-weighting system is used for measurement of environmental noise and is the manner in which the measured level is corrected to more accurately reflect the sensitivity of human hearing. Birds are considered to have a similar hearing range to that of humans and A-weighted measurements are generally used in bird studies (Drewitt et al., 2018).

L_{AMax} and L_{Amin} are an approximation of the maximum and minimum noise level recorded during a given period of assessment; they represent an average level recorded over the monitoring period.

L_{Aeq} is different to the measurements above as it is a measure of the actual sound energy rather than a statistical measure. L_{Aeq} describes a sound level with the same energy content as the fluctuating acoustic signal over a fixed time period, which equates to the mean noise level. L_{Aeq} is the equivalent level of steady, continuous noise which produces the same amount of sound energy as a fluctuating noise over the same period. This measurement can be used to describe 'ambient' noise level, although it provides no information on the number and maximum amplitude of peaks in noise emissions.

L_{APeak} is the peak sound pressure measurement and important to assess the potential startle effect of impulse noise on birds (Drewitt et al., 2018).

The measurements were undertaken by a Principal Noise Consultant with over 20 years' experience in the measurement and assessment of noise and vibration, with a specific specialism in construction noise. An Ecologist was also present during the measurements, who monitored bird behaviour during the measurement period.

4.5.2.2 Noise Monitoring during Ground Investigation Works

Noise monitoring at one location was undertaken while GI works were being carried out at the Port of Grangemouth. On 30 October 2019, during high tide, a measurement was taken within the vicinity of an active borehole on North Shore Road (Figure 11) to gain an understanding of the noise levels experienced by the birds during GI works. Measurements were taken for 15 minutes following the methods described in Section 4.5.2.1.

4.5.2.3 Potential Construction Noise Levels

The typical noise attenuation during different phases of construction work was assessed to help determine the likely effects these noise levels would have on qualifying features of the SPA. Table 4.6 details the possible plant and equipment used for the noise calculations that could be used for each phase of construction, the estimated daily duration the plant may be in use, and the sound power level at source of each item of plant (L_w dB).

Calculations were informed by the proposed construction methods and the construction methodology contained in Annex F of the Code of practice for noise and vibration control on construction and open sites (British Standards Institution, 2014), specifically the method using 'Sound Power Levels'.

Table 4.6: Possible plant and equipment details and sound level.

Phase	Activity	Plant Description	No.	% On-time	Shift Duration (h)	Duration of Activity (h)	% Activity Time	Total Lw dB
Site Compound - Excavation Hardstanding & Offices Installation	Earthworks	Dozer 20t	1	20%	10	8	80%	109
	Trenching	Tracked excavator 21t	1	25%	10	8	80%	99
	Material Distribution	Dumper 6t	1	20%	10	8	80%	107
	Rolling & Compaction	Vibratory roller 12t	1	20%	10	8	80%	108
	Lifting	Lorry with lifting boom 6t	1	30%	10	8	80%	105
	Power for Site Cabins	Diesel generator	1	50%	10	8	80%	88
Site Compound - Operation	Power for Site Cabins	Diesel generator	1	50%	10	8	80%	88
	Vehicles	General 4x4	2	20%	10	8	80%	111
	Material Distribution	Lorry (4-axle wagon)	1	10%	10	8	80%	108
Embankment Construction	Earthworks	Tracked excavator 25t	1	30%	10	8	80%	105
	Vibro piling	Vibratory piling rig 52t	1	35%	10	8	80%	116
	Material Distribution	Lorry (4-axle wagon)	1	20%	10	8	80%	108
	Rolling & Compaction	Roller (rolling fill) 18t	1	20%	10	8	80%	107
	Material Distribution	Wheeled backhoe 9t	1	15%	10	8	80%	95
	Material Distribution	Dumper 9t	1	15%	10	8	80%	104
Sheet Pile Walls	Earthworks	Tracked excavator 25t	1	25%	10	8	80%	105
	Vibro piling	Vibratory piling rig 52t	1	30%	10	8	80%	116
	Cutting steel	Gas cutter	1	10%	10	8	80%	96
	Mixing Concrete	Concrete mixer truck	1	15%	10	8	80%	108
	Concrete Other	Poker vibrator	1	10%	10	8	80%	106
	Power for Lighting	Diesel generator	1	15%	10	8	80%	93
	Material Distribution	Dumper 9t	1	20%	10	8	80%	104
Flood Walls (Formwork Reinforcement & Concrete)	Breaking Stud Partition	Lump Hammer	1	5%	10	8	80%	97
	Cutting concrete	Circular saw	1	10%	10	8	80%	107
	Mixing Concrete	Concrete mixer truck	1	25%	10	8	80%	108
	Concrete Other	Poker vibrator	1	15%	10	8	80%	106
	Power for Lighting	Diesel generator	1	20%	10	8	80%	93
	Material Distribution	Dumper 9t	1	15%	10	8	80%	104
	Earthworks	Tracked excavator 25t	1	30%	10	8	80%	105

Phase	Activity	Plant Description	No.	% On-time	Shift Duration (h)	Duration of Activity (h)	% Activity Time	Total Lw dB
Coastal Revetment	Material Distribution	Lorry (4-axle wagon)	2	25%	10	8	80%	111
	Earthworks	Tracked excavator 40t	1	40%	10	12	120%	107

Calculations have not been undertaken for distances in excess of 300m. Cutts et al. (2013) derived Diagram 3.1 based on their observed responses of waterbirds to various noise stimuli to show standard distance decay rates for noise. Acceptable levels (up to 70dB(A)) are shaded green with dark green unlikely to have any effect and light green occasionally resulting in a low-level behavioural response, for example heads-up. Diagram 3.1 shows that at 170.67m, only plant emitting 120dB(A) levels will be at an unacceptable level. It is not anticipated that plant emitting 120dB(A) at source will be used (Table 4.6) and therefore acceptable noise levels during construction of the Scheme should be experienced from approximately 170m from works. A ZoI of 300m is therefore precautionary in the context of noise disturbance.

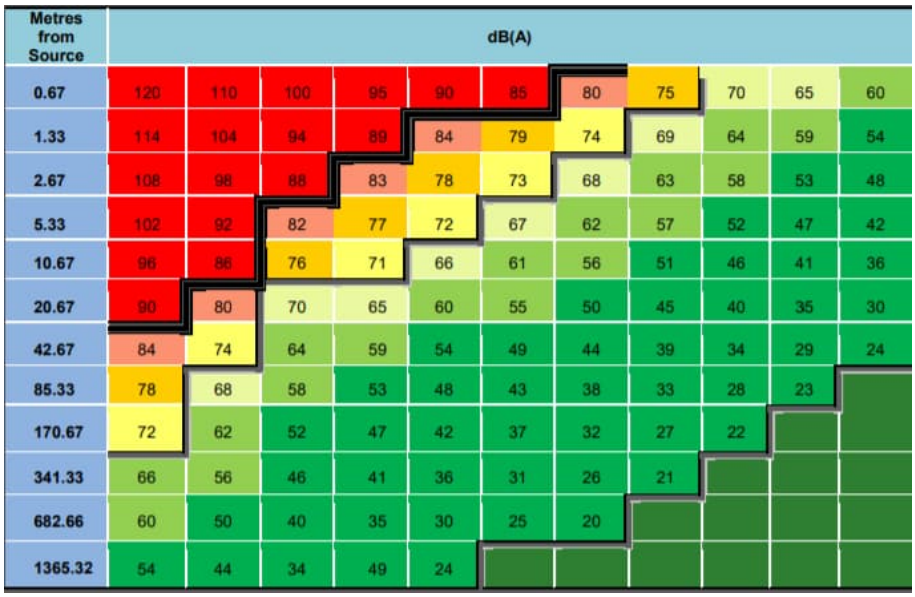


Diagram 3.1: Standard distance decay rates for noise from source (Cutts et al., 2013).

The measured baseline levels collected were used alongside the calculated potential construction noise levels to determine potential impacts on qualifying species of the Firth of Forth SPA/Ramsar site, and cormorant which are known to travel to the Firth of Forth from Loch Leven SPA/Ramsar site.

4.5.3 Results

4.5.3.1 Site Monitoring

Noise Measurements

The baseline noise levels recorded are detailed in Table 4.7. Levels recorded in the vicinity of measurement Locations A-C around the Port of Grangemouth were typical of industrial areas, with considerable impact from HGVs and other industrial activities. There were occasional high noise events, for example a ship warning horn recorded at Location B.

Location D close to the petrochemical plant was acoustically different to those around the port, with lower noise levels experienced and peaks in activity experienced as a result of train shunting activities in a nearby railway yard.

Table 4.7: Date, time and duration of each measurement and a summary of the results at each location

Location	Date and Time	Duration	Measured Noise Levels, dB						
			LAPeak	LAMax	LAMin	LAeq	LA10	LA50	LA90
A – North Shore Road	29 October 2019, 14:12	2 hours	96.5	84.4	44.7	63.2	63.3	55.9	52.7
B – North Shore Road	31 October 2019, 12:44	2 hours	103.3	84.0	45.6	54.5	53.9	50.3	48.6
C – South Shore Road	31 October 2019, 09:22	2h 2m	94.2	76.6	41.9	50.1	49.9	45.7	44.2
D – petrochemical plant	30 October 2019, 11:19	1h 56m	97.0	73.8	38.5	48.3	48.5	45.6	43.6

Bird Monitoring

Observations from bird monitoring during the measurement period are presented in Table 4.8. Weather conditions during each measurement are detailed in Appendix B (Ornithological Information).

Table 4.8: Behavioural observations from bird monitoring during noise monitoring.

Location	Tidal Cycle	Observations
A	High	From the commencement of monitoring, there was noise from forklift trucks operating at a fish pellet plant and a crane being repaired on the opposite side of South Shore Road from the monitoring location. General road traffic noise and noise from trucks was also experienced. Monitoring took place during a spring tidal cycle (very high tide). Very few birds were present in the area which was likely due to high tide. Between 14:30 – 14:40 all waders flew upstream as the tide covered all of the breakwater except for the top of the stone towers and posts. Gulls and shelduck were recorded in the far distance beyond Skinflats. The closest qualifying species to the noise monitoring position were redshank and dunlin roosting on the stone towers/posts of the breakwater (approximately 125m from surveyor), and the occasional feeding cormorant in the River Carron channel. There was no observable reaction from the species present to any noise experienced during the monitoring period.
B	Mid	At the beginning of the monitoring period, a high frequency noise from pressure washing was recorded. Other noises recorded during the monitoring period included a ship's horn, traffic, metallic bangs and passing aircraft. The closest aggregation of qualifying species was approximately 100m from the noise monitoring position on the mudflats either side of the River Carron. Wader flocks (from 2 – 200 birds, mostly redshank) moved away from the breakwater as the tide rose to the near side of the River Carron and flew away upstream. Redshank were unsettled for the duration of the monitoring period, flying from foraging on the mudflats on the east bank of the river, to feeding on the far side of the breakwater. The redshank may have been exhibiting predator avoidance behaviour because of the presence of four herons. There was no observable reaction from the species present to any noise experienced during the monitoring period.
C	Low	At 10:00 there was a controlled explosion at Longannet Power Station which is approximately 2km from the monitoring location on the other side of the estuary. Other noise experienced during the monitoring period included car horns and industrial noise from within the chemical plant. The monitoring took place at low tide and only small numbers of qualifying species (redshank and curlew) were present, the closest being approximately 100m from the noise monitoring position on the mudflats. There was no observable reaction from the species present to any noise recorded during the monitoring period.
D	Mid	Most of the noise experienced was from shunting operations in the rail depot within the petrochemical plant. The nearest qualifying species were approximately 200m away on the mudflats. As the tide rose, curlew, black-tailed godwit and shelduck flew closer to the noise monitoring position to roost in the upper shore area. There was no observable reaction from the species present to noise produced from shunting or other noises recorded.

4.5.3.2 Noise Monitoring during GI

Measurements were taken for 15 minutes within the vicinity of borehole BHFP08 on North Shore Road (Table 4.9). The measurement location was on the verge on the opposite side of the road from the port. The road was subject to traffic control during the GI works and passing port traffic also influenced the measurement.

Table 4.9: Results of noise monitoring undertaken adjacent to an active GI location (borehole)

Location	Date and Time	Duration	Measured Noise Levels, dB						
			LAPeak	LAMax	LAMin	LAeq	LA10	LA50	LA90
BHFP08 – North Shore Road	30 October 2019, 15:00	15 minutes	120.6	97.8	66.0	76.4	74.4	70.8	69.3

During the short period of noise monitoring at an active borehole GI location, noise experienced was from running engines, noises from metal casings being installed and a road sweeping vehicle passing. Qualifying interests were present on the breakwater approximately 150m from the noise monitoring location. Flocks of dunlin and redshank

flew between the towers of the breakwater which were the only parts of the breakwater above high tide. There was no observable reaction from the species present to any noise experienced during the monitoring period.

4.5.3.3 Potential Construction Noise Levels

The distance from the construction site boundary at which construction noise levels would be 60dB, 70dB and 80dB, without mitigation, for each phase of construction are detailed in Table 4.10 and shown on Figures 13-18. It should be noted that the calculated distances indicate a worst-case scenario. In this instance this is defined as all plant and equipment for each phase of construction operating as a cohesive unit, at the stated 'On-times' for the full working day, and that all plant is operating at the closest assumed point for those operations. Therefore, these distances will be the maximum distance at which the particular noise level will be experienced, and if the noise levels do reach this distance, it would be for a short period of time.

Table 4.10: Distances for given activities to certain noise levels

Phase	Distance to Stated Noise Level (m)			Figure Reference
	80dB	70dB	60dB	
Site Compound - Excavation Hardstanding & Office Installation	8	25.5	70	13
Site Compound - Operation	6.5	20	57	14
Embankment Construction	15	45	125	15
Sheet Pile Walls	14	41	113	16
Flood Walls (Formwork Reinforcement & Concrete)	6.5	20	57	17
Coastal Revetment	10	30	85	18

4.5.4 Discussion

Cutts et al. (2013) states that for auditory disturbance to qualify as a high noise level effect it must constitute a prolonged noise level of over 72dB, moderate noise level effects would be regular noise of 60-72dB and low noise level effects would be <55dB (all at the bird, not the source of the noise). The baseline noise monitoring recorded L_{Aeq} noise levels across the site ranging between 48.3dB and 63.2dB at the edge of the estuary, demonstrating that the birds present in the Firth of Forth currently experience, and have habituated to, lower than moderate noise levels.

High noise level effects can also be experienced when there are sudden noise events of over 60dB (at bird, not at source) (Cutts et al., 2013). The L_{APeak} noise levels recorded at the edge of the estuary ranged between 94.2dB and 103.3dB. No observable reaction from the birds was recorded during monitoring, suggesting that the qualifying species have habituated to high noise levels emitted from the Port of Grangemouth and petrochemical plant.

Figures 13-18 show where acceptable noise levels (≤70dB) will be experienced for six phases of construction. Embankment construction would be the 'noisiest' phase of construction, with noise levels up to 70dB being experienced the furthest (up to 45m from works). As detailed in Section 4.3.10, large aggregations of birds were recorded at four locations; the breakwater adjacent to the port (more than 50m from the Scheme), the sheltered bay adjacent to the petrochemical plant (more than 50m from the Scheme), Bothkennar Pools (more than 300m from Scheme), and the mudflats and creeks at the mouth of the River Avon. Construction noise levels are predicted to attenuate to 70dB at 45m for embankment construction, 41m for sheet pile walls, and at 30m for coastal revetment works (Figures 15, 16 and 18) – the noisiest activities adjacent to the estuary. These calculations further demonstrate that a ZoI of 300m from works is precautionary in the context of noise disturbance.

Table 4.9 identifies that the noise monitoring during GI works recorded L_{Aeq} noise levels of 76.4dB, which is above the acceptable noise levels of ≤70dB identified by Cutts et al. (2013). As the noise measurements at the borehole location were only recorded for 15 minutes; a true representation of the L_{Aeq} levels (ambient noise levels) experienced during GI works was unlikely to be obtained in this time. The measurement was taken from the edge

of the estuary, i.e. the closest a bird could experience the noise, and in this area, birds favour the breakwater which is 50m-150m from the Scheme. As shown in Table 4.10, embankment construction, the loudest construction activity, will reach acceptable levels at 45m from source (Figure 15). Therefore, noise levels experienced at the breakwater during GI works would likely be at acceptable levels of ≤70dB.

4.6 Biotope Mapping

4.6.1 Introduction

In their response to the Scoping Report (Jacobs, 2018), NatureScot advised that biotope mapping of areas affected by the Scheme should be undertaken in order to fully assess the importance of these areas to the qualifying species of the SPA/Ramsar. A biotope is a classification based on a combination of the physical environment and the associated biological community. The Marine Habitat Classification for Britain and Ireland (Connor et al., 2004) is a hierarchical classification system and is compatible with the European nature information system (EUNIS) habitat classification system. Biotope mapping is used as a tool for the assessment, management and conservation of marine habitats and in this case has been undertaken to identify the most important areas for the qualifying species of the SPA/Ramsar site that may be affected by the Scheme.

4.6.2 Methods

Core samples were collected from the intertidal mudflats at five sites; two on Skinflats and three in front of the petrochemical plant (Figure 19). Mapping was restricted to the mudflats and did not consider the extreme upper shore which, in the area in front of the petrochemical plant, predominantly consisted of a thin band (around 10m wide) of artificial erosion protection and coarse sediments (Photograph 4.1). Samples were taken using a 0.01m^2 core, preserved using formalin and sent to the laboratory for infaunal analysis. Three replicate cores were taken at each of the five sites. A sediment sample was also taken from each of the five sites and sent to National Laboratory Services (UKAS accreditation no. 0754) for particle size analysis. The species and abundance data were then combined with the results of the particle size analysis to assign a biotope to each of the five sites, in accordance with Connor et al. (2004).

Photograph 4.1. View of the upper shore in front of the petrochemical plant.

Intertidal core sampling for biotope mapping was undertaken on 09 and 10 April 2019 to coincide with midday low tides. The date of collection and location for each site is detailed in Table 4.11.

Table 4.11: Date and location core samples were taken

Site	Date	Location	
		X	Y
Site 1	09/04/2019	293113	682923
Site 2	09/04/2019	293158	682952
Site 3	10/04/2019	295429	682466
Site 4	10/04/2019	295547	682066
Site 5	10/04/2019	295921	681553

4.6.3 Results

The results of the taxonomic analyses are shown in Table 4.12. The sediment at all five sites was classified as slightly gravelly sandy mud. Taxa common to all sites were Nematoda, polychaete worms of the Eteoninae sub-family, *Hediste diversicolor* and *Streblospio* species, the small mud snail *Peringia ulvae* and the bivalve *Limecola* (previously *Macoma*) *balthica*. Ostracods of the order Podocopida, and the oligochaete, *Tubificoides benedii*, were recorded only from the two sites at Skinflats, not from the sites in front of the petrochemical plant. Cirratulid worms (including *Tharyx* species) were recorded only from the sites in front of the petrochemical plant, not from the sites on Skinflats. Taxon richness (the number of taxa recorded) was relatively low at each site (between 13 and 18 taxa) and the evenness score (which ranges from 0 – no evenness to 1 – complete evenness) show that the sites have a few dominant taxa. Taxon diversity (Simpson's Index, which takes into account taxon richness and evenness and ranges from 0 – infinite diversity to 1 – no diversity) was relatively high at all sites, 0.191 – 0.373.

The results of the sediment and infaunal analyses indicate that the intertidal benthic community at each of the five sites fit most closely with the *Hediste diversicolor* and *Limecola balthica* in littoral sandy mud biotope (LS.LMu.MEst.HedMac).

Table 4.12: Infaunal analyses of intertidal core samples (abundances are for combined replicates (i.e. 0.03m^2)).

Taxon	Site 1	Site 2	Site 3	Site 4	Site 5
NEMERTEA	-	7	2	2	10
NEMATODA	155	102	10	269	125
Pholoe sp.	-	-	-	-	1
Eteoninae	24	26	33	22	73
Eteone longa agg.	-	-	-	-	1
Nereididae juv.	-	-	-	1	11
Hediste diversicolor	5	18	3	3	12
Polydora sp.	-	-	-	1	-
Spio sp.	-	-	-	1	-
Streblospio sp.	44	46	55	12	37
Cirratulidae	-	-	-	1	11
Tharyx sp.	-	-	10	1	76
Tharyx killariensis	-	-	-	-	11
Heteromastus filiformis	3	1	1	-	24
Naididae	1	-	2	-	-
Paranais litoralis	5	-	-	2	-
Tubificoides sp.	-	1	-	-	-
Tubificoides benedii	17	8	-	-	-
Enchytraeidae	-	-	1	14	-
Podocopida	4	17	-	-	-
Corophium volutator	55	-	1	8	1
Cephalaspidea	-	-	-	-	1
Peringia ulvae	331	268	113	139	253
Limapontia sp.	4	15	2	1	-
Limapontia juv.	7	18	1	3	1
Bivalvia sp.	-	-	-	-	4
Limecola balthica	23	73	14	18	57
Animalia eggs	Present	Present	Present	-	Present
Total	678	600	248	498	709
Taxon Richness	14	13	14	17	18
Evenness	0.609	0.696	0.622	0.488	0.698
Taxon Diversity (Simpson's Index)	0.304	0.253	0.278	0.373	0.191

4.6.4 Discussion

The mudflats around Kincardine are historically well studied and evidence of effects of pollution on the benthic community have been observed, however, improvements in effluents have corresponded with increased species diversity at Grangemouth between 1976 and 1999. Davis (2001) reported that in 1999 only the inner corner of the Grangemouth mudflat, adjacent to the refinery outfall, showed any impacts from the effluent with a lower number and diversity of species compared to the rest of the mudflat. Site 3 from the present study, which was located in the inner corner, did exhibit lower total abundance than all other sites. However, while taxon richness

was slightly lower than Sites 4 and 5 on the Grangemouth mudflat, it was similar to that recorded at Sites 1 and 2 on Skinflats. Davis (2001) also demonstrated that the benthic community of the upper shore around Grangemouth and Kinneil was less diverse and had lower abundances than the lower shore, suggesting that the abundances and diversity recorded in this study may be a conservative indication for the mudflat as a whole.

In context of the wider Forth Estuary, it is reported that 74% (4672.12ha) of the Firth of Forth Ramsar site is mudflat habitat (NatureScot, 2023b), with Skinflats, Grangemouth and Kinneil Kerse accounting for approximately 1,051ha of this. Indicative mudflat locations in the wider estuary (Bennet and McLeod, 1998; Marine Scotland, 2020; McLusky et al., 1993; Zoutenbier et al., 2016) are shown in Figure 19. Historic studies describe the shores of the upper estuary above Kincardine Bridge as narrow and organically enriched with high abundances of oligochaetes, while the middle estuary shores between the Kincardine and Forth bridges are the most productive, and the lower estuary has the greater species diversity but lower biomass (review by Bennet and McLeod, 1998). A comparison of the benthic community composition at Grangemouth and Kinneil against other mudflats, both within the Forth Estuary and around the UK found that Grangemouth and Kinneil were similar to other sites in the Forth and Montrose Basin, which was also classified as having Bad water quality (based on Environment Agency classifications) at the time (Davis, 2001). The community composition at Grangemouth and Kinneil differed from those estuaries with Good water quality classifications (such as the Loughour and Eden), with higher abundances of *Manayunkia aestuarina* at Grangemouth one of the main contributors. This opportunistic polychaeate increased in abundance following a change in outfall locations at Grangemouth in the 1970s but was absent from the samples in this study. This may be an indication of further improvements in water quality around Grangemouth, but with a limited data set that cannot be said with confidence.

Biotope classifications for the intertidal areas of the Forth Estuary are not widely available for comparison. Studies conducted to inform the Environmental Statement for the Forth Replacement Crossing (Transport Scotland, 2009) identified extensive areas of sedimentary biotopes on both the northern and southern shores of the estuary, which were classified as the species-rich mixed sediment shores (LS.LMx.Mx) biotope and were dominated by the polychaetes *Pygospio elegans* and *Mediomastus fragilis* and the cockle *Cerastoderma* sp. An SNH survey in 2001 classified the intertidal mudflat areas between Cramond and the Forth Rail Bridge as *Hediste diversicolor* and *Limecola balthica* in littoral sandy mud (LS.LMu.MEst.HedMac) (Marine Scotland, 2020), the same biotope as identified at Skinflats and Grangemouth. Windylaw Bay, on the western side of Rosyth Dockyard was identified as a mosaic of intertidal habitats, with large areas of littoral sediment biotopes including polychaete/bivalve dominated mid estuarine mud shores (LS.LMu.MEst) (Jacobs, 2011). The biotope recorded by at Grangemouth and Skinflats is a sub-biotope of this overarching classification.

All of the taxa recorded in the present study are typical of intertidal estuarine mudflats and none are of particular note or conservation interest. The LS.LMu.MEst.HedMac biotope, is assessed as having high resilience to most pressures, meaning that full recovery will normally occur within two years after removal of the pressure (Tillin and Rayment, 2016). The characterising species of this biotope, *H. diversicolor* and *L. balthica,* have a reproductive lifecycle of one to two years and recovery of a habitat can occur through recovery of damaged individuals, adult migration from adjacent habitats or recolonisation of larvae. Lewis et al. (2002) found complete defaunation at one month following pipeline construction on intertidal mudflats in Clonakilty Bay, Ireland. However, six months after construction there was no significant difference between the construction site and the control sites, with *H. diversicolor* the first species to recolonise the area. Following managed realignment at Kennet Pans in 2007, benthic invertebrates (*Limecola*, *Corophium*, *Hediste* and *Hydrobioa*) were found to have colonised the newly created habitat by the second winter post-construction (Dwyer, 2010). This suggests that areas of mudflat disturbed during the construction phase of the Scheme will be expected to recover quickly post-construction.

Of the dominant species recorded in this study, the molluscs *P. ulvae* and *L. balthica*, were indicated by Medonca et al. (2007) as potential preferred food sources for shorebirds in the Culbin Sands lagoon in the Moray Firth. It is therefore plausible that these species are also among the preferred prey items for several shorebirds in the Firth of Forth including bar-tailed godwit, knot, redshank and shelduck. These mollusc species have been recorded at similar abundances to Grangemouth in other areas of the Firth of Forth such as Torry Bay, Skinflats and Kincardine (Davis, 2001; McLusky et al., 1993).

4.7 Effects Pathways: Firth of Forth SPA and Ramsar Site

LSEs identified at Stage 1 (Screening) that might compromise the conservation objectives of the Firth of Forth SPA/ Ramsar site are:

- direct habitat loss; and
- disturbance and displacement (noise, vibration and visual) leading to indirect habitat loss.

4.7.1 Habitat Loss

Construction of the Scheme could result in the loss or localised fragmentation of foraging and roosting habitat. This could have a negative impact on birds that require the habitat and associated fauna for foraging, or rely on intertidal areas at the estuary edge as roosting habitat.

The Site Boundary for construction of the Scheme overlaps the SPA/Ramsar site for a total of 1.58ha. Of this, 0.43ha will be temporarily lost and 1.15ha will be permanently altered. Throughout the iterative design process, efforts have been made to reduce land take from the SPA. This includes altering the design of coastal revetment defences around the estuary edge from a 1:3 slope to a 1:1.5 slope and minimising the construction area available to only what is required to feasibly facilitate plant movement and construction.

4.7.1.1 Temporary Habitat Loss

Construction of the Scheme will result in the temporary loss of 0.43ha of SPA habitat. This area will be restored, and the upper shore habitat allowed to recolonise post construction. Of the 0.43ha, the UK Habitat Classification survey conducted for the Scheme identified that 0.27ha is marine inlets and transitional waters comprising mudflats (0.25ha), saltmarsh (0.02ha) and beach (<0.01ha) (collectively shown as UK Habitat type t in Diagram 4.1 below). The remaining 0.16ha of SPA habitat lost under the temporary footprint of the Scheme is made up of urban areas, wetland, grassland and river habitat (Diagram 4.1).

Mudflat habitats are an important foraging resource for many qualifying species of the SPA. The mudflat habitat that will be lost is widespread throughout the estuary. The biotope survey (Section 4.6) found that the intertidal mudflat areas in proximity to the Scheme fit most closely with the *Hediste diversicolor* and *Limecola balthica* in littoral sandy mud biotope and is not of conservation interest or of particular note with regards to previously reported communities in the Forth Estuary. This aligns with the findings of Davis (2001) and Bennet and McLeod (1998) who demonstrated that the benthic community of the upper shore around Grangemouth and Kinneil was less diverse and lower in abundances than the lower shore. This biotope is assessed as having high resilience to most pressures and therefore, where temporary impacts are predicted, full recovery can be expected within two years after removal of the pressure. Due to the resiliency of the mudflat habitats, minimal usage by roosting or foraging birds compared to other much more heavily used areas, and widespread availability of this habitat within the estuary, temporary loss of 0.25ha will not adversely impact qualifying species.

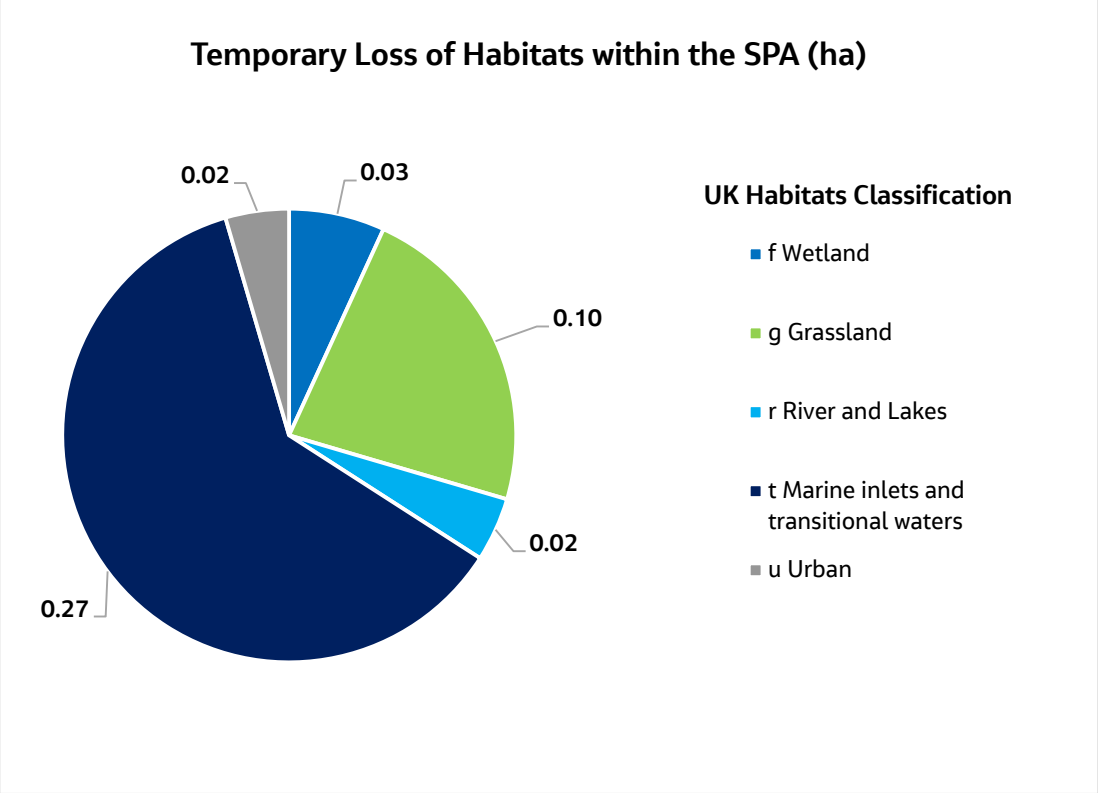


Diagram 4.1: Habitats within the SPA temporarily lost during construction of the Scheme.

4.7.1.2 Permanent Habitat Alteration

Permanent habitat alteration from the SPA has been identified as all land under the permanent footprint of the Scheme which overlaps with the Firth of Forth SPA and Ramsar boundary. The current design would result in the permanent alteration of 1.15ha of SPA and Ramsar habitat: the areas permanently altered are shown on Figure 21 and are broken down by Flood Cell in Table 4.13.

In Flood Cell 6, this includes areas of SPA habitat that will be permanently altered as a result of ground improvement works (see Section 2.4.4.2). In locations where access is restricted in Flood Cell 6, permanent habitat loss also includes the provision of a 3m wide permanent access track to be constructed on the dry side of the defence. The exact location of the access track is currently unknown but will be constructed between the flood wall and the pipelines.

Table 4.13: Permanent habitat loss/alteration within the SPA by Flood Cell.

Flood Cell	Location	Area (ha)
3	Very small areas adjacent to North Shore Road and adjacent to the lock gate, within the Port of Grangemouth.	0.10
5	Adjacent to the petrochemical plant fenceline in Working Area 5-1 (Mouth of the River Avon).	<0.01
6	Adjacent to the petrochemical plant fenceline in Working Areas 6-1 (Beech Road) and 6-2 (Petroineos Mouth of River Avon).	1.04
Total		**1.15**

Of the 1.15ha, 0.89ha is marine inlets and transitional waters comprising mudflats (0.59ha), saltmarsh (0.25ha) and beach (0.05ha) as detailed in the UK Habitat Classification survey data collected for the Scheme (collectively

shown as Habitat type t in Diagram 4.2 below). The remaining 0.26ha of SPA habitat lost under the permanent footprint of the Scheme is made up of urban areas, wetland, grassland and river habitat (Diagram 4.2).

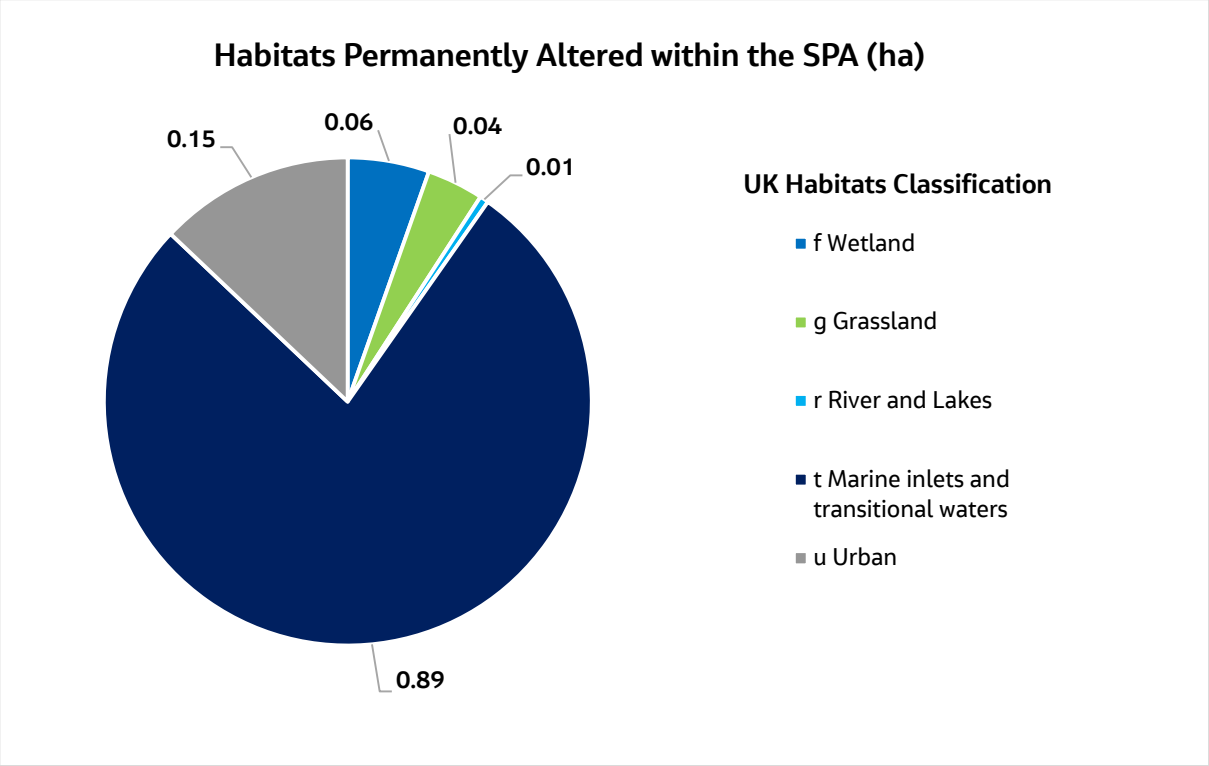


Diagram 4.2: Habitat types within the SPA permanently altered under the footprint of the Scheme.

4.7.1.3 Habitat Utilised by Qualifying Species

To assist in determining whether the temporary and permanent habitat alterations would impact the qualifying species, the bird survey data has been utilised to identify which qualifying species have been recorded within the SPA areas that fall within the temporary Site Boundary (Table 4.14) and permanent footprint of the Scheme (Table 4.15). The majority of records were along the shore to the east of the petrochemical plant.

Figure 20 identifies the location of peak counts for each species within the area where the Site Boundary temporarily encroaches upon the SPA during construction. Figure 21 identifies the location of peak counts within the SPA habitat that will be permanently altered. The number of birds recorded in these peak counts is also provided on each figure – the information on Figures 20 and 21, aligns with the peak counts for each species in Table 4.14 and Table 4.15 respectively.

Within the habitat unavailable during construction, eight qualifying species were recorded roosting and foraging: cormorant, dunlin, knot, lapwing, mallard, redshank, shelduck and wigeon (Figure 20). Knot was only recorded during the 2015/16 and 2016/17 surveys, whilst wigeon was only recorded during the 202/23 surveys. The remaining six species were recorded in both surveys.

Within the habitat permanently altered habitat, the same eight qualifying species were recorded. Cormorant, knot and lapwing were only recorded during the 2015/16 and 2016/17 surveys, whilst mallard and wigeon were only recorded during the 2022/23 surveys (Figure 21).

The data identifies that birds of certain species do make some use of the areas that will be temporarily unavailable or permanently altered. Numbers are generally low and relate mainly to high tide records, indicating roosting behaviour. The data also show that relatively large numbers of dunlin can occasionally turn up to roost in these locations. However, as the records are 'point' records, the size of the area occupied by the large dunlin flock (and some other flocks) most likely spreads out into areas of unaffected habitat - the peak counts in some instances

show higher numbers of birds than actually make use of the affected areas. The proportion of estuary edge habitat directly affected is very small compared to the extent of suitable available alternative habitat nearby, and the revetment wall will itself offer roosting opportunities for birds.

Rock armour revetment defences will be implemented in areas north and east of the petrochemical plant (see Figure 7 for design information), which will provide roosting opportunities for the majority of qualifying species.

Table 4.14: Peak counts of qualifying species recorded within SPA habitat that the Scheme will temporarily encroach upon during construction. Peak counts of 2015/16 and 2016/17 survey data shown in white rows and peak counts for 2022/23 survey data are shown in green rows.

Species	Peak Count	% of Cited SPA Population	Month	Year	Sector	Tide
Cormorant	6	0.88	March	2017	10	Rising
Cormorant	11	1.61	August	2022	6	Rising
Dunlin	8000	84.09	December	2016	10	High
Dunlin	1	0.01	January	2023	10	High
Knot	40	0.43	December	2015	10	High
Knot	0	N/A	N/A	N/A	N/A	N/A
Lapwing	75	1.81	January	2017	10	High
Lapwing	35	0.84	August	2022	6	Rising
Mallard	20	0.78	January	2016	10	Rising
Mallard	4	0.16	March	2023	9	High
Redshank	266	6.13	February	2017	10	High
Redshank	165	3.80	February	2023	10	High
Shelduck	168	3.73	September	2016	9	Low
Shelduck	2	0.04	March	2023	9	High
Wigeon	0	N/A	N/A	N/A	N/A	N/A
Wigeon	12	0.56	January	2023	12	Rising

Table 4.15: Peak counts of qualifying species recorded within SPA habitat that will be permanently altered. Peak counts of 2015/16 and 2016/17 survey data shown in white rows and peak counts for 2022/23 survey data are shown in green rows.

Species	Peak Count	% of Cited SPA Population	Month	Year	Sector	Tide
Cormorant	6	0.88	March	2017	10	Rising
Cormorant	0	N/A	N/A	N/A	N/A	N/A
Dunlin	8000	84.09	December	2016	10	High
Dunlin	1	0.01	January	2023	10	High
Knot	40	0.43	December	2015	10	High
Knot	0	N/A	N/A	N/A	N/A	N/A
Lapwing	75	1.81	January	2017	10	High
Lapwing	0	N/A	N/A	N/A	N/A	N/A
Mallard	0	N/A	N/A	N/A	N/A	N/A
Mallard	2	0.08	March	2023	9	High
Redshank	266	6.13	February	2017	10	High
Redshank	165	3.80	February	2023	10	High
Shelduck	168	3.73	September	2016	9	Low
Shelduck	2	0.04	March	2023	9	High
Wigeon	0	N/A	N/A	N/A	N/A	N/A
Wigeon	12	0.56	January	2023	12	Rising

4.7.2 Disturbance

Unlike the direct impacts associated with habitat removal or deterioration, disturbance does not directly affect the physical conditions of a site; it concerns the species and it may be limited in time (noise, source of light etc.). The intensity, duration and frequency of repetition of disturbance are therefore important parameters in the implications for species from the disturbance stimuli.

The overall objective of the Birds Directive is that '*Member States shall take the requisite measures to maintain the population of the species…at a level which corresponds in particular to ecological, scientific and cultural requirements, while taking account of economic and recreational requirements, or to adapt the population of these species to that level.*' This can be interpreted as being equivalent to favourable conservation status of a species, as

a key measure for achieving favourable conservation status is the European site network, which includes SPAs designated under the Birds Directive (JNCC, 2018). Therefore, to assess whether a disturbance is significant in relation to the conservation objectives of the site, reference can be made to the definition of the favourable conservation status of a species given in Article 1(i), on the basis of the factors below.

- '*Population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable element of its natural habitat*s'.
- Any event, activity or process contributing to the long-term decline of the population of the species on the site can be regarded as a significant disturbance.
- '*The natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future*'.

Any short, medium or long-term event, activity or process contributing to the reduction or to the risk of reduction of the range of a species within the site can be regarded as a disturbance and any event, activity or process contributing to the reduction of the size of the available habitat of the species can also be regarded as a disturbance. However, whether these disturbances would affect the population in the long term is dependent on whether there is, and will continue to be, a sufficiently large area of habitat to maintain its populations on a long-term basis.

Factors such as intensity, frequency and duration of the disturbance may be taken into account to determine its significance, which may vary from one species to another and according to different times and different conditions (e.g. food resources, or through the presence of sufficient undisturbed areas nearby). In that regard, for the Firth of Forth SPA, effects such as noise, vibrations and visual stimuli from the construction of the Scheme are capable of causing significant disturbances for the qualifying bird species. Any long-term effects from such disturbance can be related to the:

- timing of the disturbance in the context of the life cycle of the species;
- susceptibility of a species to disturbance and implications for fitness and fecundity from this susceptibility;
- functional importance of the habitat disturbed to the species affected; and
- in combination effects not just with other plans and projects but environmental factors such as severe weather events.

To understand the implications of the identified disturbance LSEs from construction and operation (maintenance activities) of the Scheme, they are being considered in the context of the site's conservation objectives and its contribution to the coherence of the network. For the disturbance from construction to have no AESI, the disturbance of a species from a short, medium or long-term effect must not compromise the other conservation objectives, which may include leading to a long-term change in the:

- population of the species as a viable component of the site (dependant on magnitude of change);
- distribution of the species within the site; and/or
- distribution and extent of habitats supporting the species.

Noise, vibration and visual effects (human and vehicle/plant movements) during construction and maintenance activities have the potential to cause disturbance and displacement of qualifying species of the Firth of Forth SPA present within the ZoI. Although studies have shown that certain bird species have the ability to habituate to regular noises and visual disturbances, potential long-term effects of disrupted foraging and roosting behaviour could lead to decreased body condition and a reduction in reproductive success and individual survival (Smit and Visser, 1993).

In terms of foraging habitat, displacement from feeding opportunities not only reduces a bird's energy intake but may also lead to an increase in stress and energy expenditure as a result of the energetic costs of flying to alternative foraging areas (Johnston et al., 2013). Displacement could also have knock-on ecological effects such as increased competition (within and/or between different species) for a common food source. Should areas be

subject to heavy or on-going disturbance, waterbirds could be disturbed so frequently that their displacement essentiality results in temporary habitat loss from that area (National Parks and Wildlife Service, 2014).

Waders are particularly vulnerable to disturbance whilst roosting during high tide (Dias et al., 2006; Whitfield et al., 2008; Catry et al., 2011; Glover et al., 2011). When disturbance effects reduce species fitness (reduced survival or reproductive success), consequences at population level may result. At certain times of year (i.e. during cold spells in the winter) the effect of this could be particularly severe, potentially resulting in bird mortality. If birds are repeatedly reacting to disturbance, over time body condition could decrease affecting mortality, emigration and reproductive success and could result in short- and/or long-term individual and population implications.

Several studies have identified different disturbance responses of bird species, linked to the type of disturbance stimuli, the bird community present and their activity, the extent and topography of the site, the time of year and weather conditions (Cutts and Allen, 1999). The hearing frequency range of birds is similar to that of humans, between 20 and 20,000Hz. Various studies show birds react to noise levels varying from 42dBA to 117dBA. Bird response to construction activity is variable, with minimum distances to disturbance from as low as 50m up to 500m (Cutts and Allen, 1999). A study by Linssen et al. (2019) found that the total distance travelled by roosting oystercatchers during a high tide period after disturbance ranged from 1km – 2.9km. This study also found that although travel distance increased during a high tide disturbance event, daily energy expenditure was only marginally affected.

Generic waterbird responses to disturbance from a range of activities including construction work have been collated and summarised in Table 4.16 and are based on observations of construction studies on the Humber Estuary (Cutts and Allen, 1999; Cutts et al., 2013).

Table 4.16: Disturbance effects on wintering estuarine birds from various construction and maintenance activities.

Activity Description	Disturbance Effect
Personnel and plant on mudflat	High
Third party on mudflat	High
Personnel and plant on seaward toe and face	High to Moderate
Intermittent plant and personnel on crest	High to Moderate
Third party on bank	High to Moderate
Irregular piling noise (above 70db)	High to Moderate
Long-term plant and personnel on crest	Moderate
Regular piling noise (above 70db)	Moderate
Irregular piling noise (50db – 70db)	Moderate
Regular noise (50db – 70db)	Moderate to Low
Occasional movement of crane	Moderate to Low
Noise below 50db	Low
Long-term plant only on crest	Low
Activity behind flood bank (inland)	Low

Disturbance effects were researched within the Forth estuary during construction of the Clackmannanshire Bridge (Dwyer, 2010) with the subsequent findings of the research used to inform the assessment of severity of disturbance effects during construction and maintenance of the Scheme. The project involved the construction of a bridge directly impacting mudflat and saltmarsh habitat utilised by birds associated with the Firth of Forth SPA. The observed responses varied between species: dunlin, curlew shelduck, wigeon, red-breasted merganser and

goldeneye numbers increased in the study area; knot, oystercatcher, and pink-footed goose showed no significant changes in numbers; and redshank, bar-tailed godwit, cormorant and lapwing showed a decrease in numbers close to the construction area. The increase in numbers for some species was attributed to the creation of new areas of habitat as part of mitigation for the project including increased nocturnal foraging ability for some species during tidal cycles as a result of construction lighting which would have otherwise been avoided.

Dwyer (2010) observed that birds in areas affected by construction noise over the estuary showed increased vigilance – thought to be a response to the construction noise masking the detection of predators. This resulted in a 19% reduction in redshank foraging time at one site. Similar effects were also noted in response to construction work on the Stirling-Alloa-Kincardine Railway (Dwyer, 2010) where reductions in foraging time were noted in response to increased vigilance to workers and vehicles on the railway (from 38% in 2008/09 to 19% in 2007/08). Additionally, juvenile redshank numbers decreased at high productivity feeding areas that were subject to disturbance during construction of the Clackmannanshire Bridge, in favour of areas further away with lower prey availability, for example at Kinneil shore. The areas which showed an increase in bird density had a lower carrying capacity for birds resulting in increased competition (within and/or between different species) for a common food source. Kincardine shore was used later in the winter due to low prey and high predation risk but was used earlier in the season during construction winters as a result of preferred habitat not being available for foraging and thus forcing birds to utilise less optimal habitat (i.e. habitat with less prey availability for foraging and within which there was a greater risk of predation along Kincardine shore).

The effects in this study appeared to be short-term (i.e. just the duration of the construction) and not impacting at the population level; numbers of redshank in the Forth were considered to have recovered in the first winter following completion of the bridge. Birds can show a variety of other responses to compensate for reduced feeding opportunities in disturbed areas: in the Forth, redshank and shelduck have been observed to increase their foraging time at mid and low tides, and shelduck also spent more time feeding in the water than on land.

Analysis of the Scheme's bird data show that there are large numbers of birds of a high diversity of species roosting within the ZoI during the winter. Key roost areas that fall within the ZoI are the rocky breakwater west of the Port of Grangemouth and the estuary edge north of the petrochemical plant (the sheltered bay). Bird species present at these locations especially could be impacted during the construction.

Birds were infrequently recorded within the ZoI during low tide, as the preferred foraging habitat (notably mudflats at Kinneil Kerse and Skinflats) are outwith the ZoI. One exception is an area at the mouth of the River Avon where birds were recorded foraging on over 150 occasions across the three survey periods. Davies (2001) demonstrated that the benthic community of the upper shore around Grangemouth and Kinneil was less diverse and with lower abundances than the lower shore which would further explain the infrequent observations of foraging birds in this location. Given the considerable area of alternative foraging habitat in close proximity to the site the potential for impacts on foraging birds at low tide is considered low. The main impacts from disturbance will be on roosting birds at high tide when birds have no choice but to move to supratidal (above the spring high tide line) roosts and are therefore at their most vulnerable, given the reduced amount of alternative habitat available at high tide.

The noise monitoring assessment shows where acceptable noise levels (≤70dB) will be experienced for six phases of construction. Construction noise levels are predicted to attenuate to 70dB at 45m for embankment construction, 41m for sheet pile walls, and at 30m for coastal revetment works (Figures 15, 16 and 18) – the noisiest activities adjacent to the estuary. Large aggregations of birds were recorded at four locations; Bothkennar Pools (more than 300 from Scheme), the breakwater adjacent to the port (more than 50m from Scheme), the sheltered bay adjacent to the petrochemical plant (more than 50m from the Scheme) and the mudflats and creeks at the mouth of the River Avon. During the noise monitoring of GI works noise levels of up to 76dB were recorded along the estuary edge during a range of ground investigation activities. No noise and visual barriers were installed during this phase of GI works, yet bird monitoring undertaken in tandem with the GI noise monitoring noted that birds roosting on the breakwater had no observable reaction to noise generated by the works. There were occasional reactions to specific noise events by birds elsewhere along the estuary edge, but no birds flew more than 30m from the disturbance. Noise levels higher than 70dB are not predicted at Bothkennar Pools, the breakwater or the sheltered bay areas which contain large aggregations of birds. At the mouth of the River Avon,

only birds within 30m of the coastal revetment works could potentially be disturbed. Therefore, this further demonstrates that a ZoI of 300m from works is precautionary in the context of noise disturbance.

4.8 Effects Pathways: Loch Leven SPA and Ramsar site

LSEs identified at Stage 1 (Screening) that might compromise the conservation objectives of the Loch Leven SPA/ Ramsar site include:

- direct habitat loss; and
- disturbance and displacement (noise, vibration and visual) leading to indirect habitat loss.

4.8.1 Habitat Loss

No land-take from Loch Leven SPA/Ramsar site is required for the Scheme. However, the Scheme has the potential for temporary habitat loss of up to 0.43ha, of which 0.25ha is mudflat habitat, within the Forth estuary. The Scheme could result in the permanent alteration of up to 1.15ha within the Forth estuary, of which 0.59ha is mudflat habitat. The loss of this supporting habitat may result in localised fragmentation/loss of habitat for qualifying species of the SPA should they utilise the Firth of Forth. Cormorant is known travel between Loch Leven and other sites, including the Firth of Forth (Wright, 2003). No other individuals of the qualifying species of Loch Leven SPA are known to travel between Loch Leven and the Firth of Forth.

The habitat lost would be proportionally small in comparison to the alternative habitat available in the Forth estuary for those species that could be affected. Studies have shown that cormorant regularly travel 45km with occasional journeys further afield (Wright, 2003) and can therefore utilise other sites.

4.8.2 Disturbance

None of the qualifying species will be disturbed as a result of the Scheme whilst wintering on Loch Leven. Cormorant may be disturbed if visiting the Firth of Forth from Loch Leven; however, individuals will be able to utilise the widely available alternative habitat in the Forth Estuary.

4.9 Assessment of Impacts

Table 4.18 assesses the potential impacts of habitat loss and disturbance/displacement identified from the Scheme on qualifying species. Species which were not recorded within the ZoI (common scoter) or study area (Slavonian grebe, long-tailed duck and velvet scoter) are not included in the assessment as no LSEs have been identified.

Habitat loss was considered in relation to the following conservation objectives of the Firth of Forth/Loch Leven SPA:

- To avoid deterioration of the habitats of the qualifying interests or significant disturbance to the qualifying interests, thus ensuring that the integrity of the site is maintained; and
- To ensure for the qualifying interests that the following are maintained in the long term:
  - distribution of the species within site;
  - distribution and extent of habitats supporting the species.

Disturbance/displacement was considered in relation to the following conservation objectives of the Firth of Forth/Loch Leven SPA:

- To avoid deterioration of the habitats of the qualifying interests or significant disturbance to the qualifying interests, thus ensuring that the integrity of the site is maintained; and
- To ensure for the qualifying interests that the following are maintained in the long term:
  - population of the species as a viable component of the site;

- distribution of the species within site;
- no significant disturbance of the species.

The potential physical and ecological effects of the Scheme were assessed to understand their implications for the conservation objectives of the Firth of Forth SPA/Ramsar site and Loch Leven SPA/Ramsar site to understand whether either site's integrity could be compromised. Cormorant are considered the only qualifying species of the Loch Leven SPA/Ramsar site that could be affected by the Scheme as they are known to travel to the Firth of Forth. As cormorant are also a qualifying species of the Firth of Forth SPA, and the conservation objectives of the two sites are the same, the assessment of impacts text will focus on the Firth of Forth SPA.

A total of 23 species were identified within the ZoI for the Scheme, for which there is a potential for LSE (or the potential for LSE cannot be excluded). For a conclusion of no adverse effects on site integrity the impacts identified must not alter the maintenance of the population of the species as a viable component of the site, the distribution of the species within site, the distribution and extent of habitats supporting the species, the structure, function and supporting processes of habitats supporting the species and ensure no significant disturbance of the species occurs.

How the area of habitat permanently or temporarily lost is used prior to construction, and if it could be utilised in a similar way post construction, will be considered to determine the implications of habitat loss on site integrity.

The implications of disturbance for site integrity is dependent on a number of factors:

- location or the distance of the development from the species of interest;
- habituation of birds to existing disturbance; and
- timing of the development.

In addition, the following was considered in the assessment:

- the number of birds displaced from the ZoI as a result of the works and to what distance, e.g. small localised movement within the SPA or movement out of the SPA. The number of birds has been represented as a percentage of the SPA population to help highlight important numbers and key locations; however, it is recognised that all qualifying species carry the same level of protection regardless of the numbers present;
- the duration of time the displaced birds are likely to be affected at the most sensitive time e.g. during the high tide period;
- the number of times displacement will likely occur, i.e. will the displacement occur constantly throughout the day or infrequently; and
- the results of the GI noise monitoring.

4.10 Mitigation

Mitigation measures aimed at avoiding or reducing adverse effects on site integrity as a result of the Scheme are detailed in Table 4.17 and key mitigation items are also summarised within Table 4.18 for each applicable qualifying feature.

Whilst some of these mitigation measures broadly align with measures included within Chapter 10 (Biodiversity) and Chapter 16 (Schedule of Environmental Commitments) of the EIA Report, mitigation presented in this document is specifically required to address potential adverse effects identified within the HRA. Falkirk Council, as the Competent Authority for the HRA, shall ensure that all mitigation or compensatory measures finalised through the HRA process form part of the Scheme construction specifications (with any additional measures identified through HRA being conditioned as part of the deemed planning consenting process on Scheme confirmation).

The application of standard mitigation commitments, legislative requirements and industry standard best practice (e.g. mitigation of potential pollution impacts through adherence to standard best practice and guidelines, such

as the SEPA Guidance for Pollution Prevention (GPPs) and Pollution Prevention Guidelines (PPGs)) (Netregs 2023) will also assist in avoiding or reducing potential adverse effects on site integrity of the Firth of Forth SPA/Ramsar site.

With regards to Mitigation Item HRA10, viewsheds have been undertaken to identify the most effective screen height, which was then considered against practicality. For example, a 4m screen would block most, if not all, of the works from view of the birds. However, maintaining this height of screen along an exposed estuary would be difficult and create potential health and safety issues during high winds. Therefore, a 2m noise and visual barrier screen will be installed prior to construction along the works areas adjacent to the estuary in front of the breakwater and sheltered bay and will remain in place for the duration of the works. Viewshed analysis shows that screens of this height reduce visibility from the works area, especially when works are taking place 'in-water' along the edge of the estuary. It is accepted that this height of screen will not conceal all activities and the top of some construction machinery will be visible, such as piling rigs and excavator arms. As noted in Section 4.4, no noise and visual barriers were installed during Phase 5 of the GI works and disturbance recorded was minimal. Noise and visual barriers 2m in height were installed as mitigation during later phases of the Scheme GI works that were conducted adjacent to the estuary in Flood Cells 2 and 6: ecologists on site during works did not observe any potentially disturbing events during the GI works that caused birds to fly away from the area. There is likely to be some level of habituation to existing activities that are taking place along North Shore Road around the Port of Grangemouth and within the petrochemical plant.

Table 4.17: Mitigation measures to avoid or reduce potential for adverse effects on the European sites network

Mitigation Item	Timing of Measure	Description	Purpose / Objective
HRA1	Pre-construction phase	An Outline Construction Environmental Management Plan (CEMP) will be prepared and made available prior to confirmation of the Scheme. Prior to construction the contractor will develop, update, and maintain the CEMP, which must be approved by Falkirk Council. The CEMP will include an Ecological Management Plan (EMP). The contractor will develop the EMP in consultation with the relevant stakeholders, including NatureScot. The EMP will include Species Management Plans which, as a minimum, will include the following: ▪ the scope of pre-construction surveys required to verify and, where required, update the baseline ecological conditions set out in this HRA. The scope of these surveys will be confirmed with Falkirk Council (and NatureScot where required) prior to them being undertaken. ▪ details of proposed mitigation measures and any required exclusion zones to avoid or reduce potential impacts on the qualifying species and any unnecessary encroachment into adjoining areas of the Firth of Forth SPA/Ramsar site. ▪ restrictions on the timing of construction works to avoid or reduce impacts on the qualifying species of the Firth of Forth SPA/Ramsar site. (HRA5 provides some additional details) ▪ appropriate watching briefs during construction as detailed in the role and expectation of the ECoW. ▪ details of proposed post-construction monitoring requirements to ensure mitigation measures are implemented and are functioning as expecting during	To ensure compliance with legislation and commitments within this HRA.

		the operational phase. The EMP will be informed by pre-construction surveys and updated as appropriate with additional mitigation measures where required. The EMP will also include a Landscape and Ecological Habitat Management Plan (LEHMP).	
HRA2	Pre-construction phase/ Construction phase	Monitoring surveys will be undertaken by the employer's ecologist across Sectors 4-11 for the winter period prior to construction works adjacent to the Firth of Forth SPA/Ramsar site. Surveys are expected to follow the Through the Tide Count (TTC) method, but the exact survey method will be determined prior to commencement, in consultation with NatureScot.	To update the baseline data collected for the Scheme, which can then be used to monitor bird responses to construction activities.
HRA3	Pre-construction phase/ Construction phase	Prior to construction a suitably qualified (or team of suitably qualified) ECoW will be appointed by the Contractor and will be responsible for implementation of an Ecological Management Plan. The ECoW will: ▪ provide ecological advice over the entire construction programme; ▪ undertake or oversee a bird watching brief for works conducted in the vicinity of the Firth of Forth SPA/Ramsar site. See HRA7 for more details. (Separate construction monitoring is detailed in HRA8 and pre-construction monitoring is detailed in HRA2); ▪ ensure mitigation measures are implemented to avoid and reduce impacts on qualifying species; and ▪ monitor the implementation of the mitigation measures during the construction phase to ensure compliance with legislation, and commitments within this HRA and the EIA Report for the Scheme. The ECoW will be a member of the Chartered Institute of Ecology and Environmental Management (CIEEM) and will have previous experience in similar ECoW roles. All ECoWs will be approved by Falkirk Council to be appropriately qualified for the role and compliance will be monitored by an employer's ecologist acting on behalf of Falkirk Council. The ECoW will be appointed in advance of the main construction programme commencing to ensure any advance mitigation measures required are implemented, in collaboration with the employer's ecologist.	To ensure compliance with legislation and commitments within this HRA.
HRA4	Pre-construction phase/ Construction phase	Any temporary lighting arrangements installed for the construction phase will be designed to ensure minimal light spill outwith the boundary of the construction sites and associated site compounds. The ECoW will monitor construction site lighting to identify any potential adverse impacts on birds. Preventative measures (e.g. installation of shields) will be taken if any adverse impacts are detected.	To avoid or reduce light disturbance to qualifying features of the Firth of Forth SPA/Ramsar site.
HRA5	Construction phase	Any works undertaken adjacent to the Firth of Forth SPA/Ramsar site within Flood Cells 3 and 6 will be undertaken independently of each other, with at least one winter in between.	To avoid or reduce noise and visual disturbance to qualifying features of the Firth of Forth SPA/Ramsar site.
HRA7	Construction phase	The ECoW will undertake or oversee a watching brief of works adjacent to the Firth of Forth SPA/Ramsar site to observe construction activities and any notable reaction of the qualifying species as a result of these.	To determine if there is any notable disturbance to qualifying features of the Firth of Forth SPA/Ramsar site and

		The ECoW will determine when to stop works and the potential requirement for any further mitigation in line with those outlined in the Bird Species Management Plan. Whilst significant disturbance to birds during works will be avoided where possible, it is acknowledged that disturbance could occur during construction; therefore, compensatory habitat has been provided.	implement appropriate mitigation where necessary.
HRA8	Construction phase	During construction, each winter where there are works adjacent to the Firth of Forth SPA/Ramsar site, monthly monitoring surveys will be undertaken by the employer's ecologist across Sectors 4-11. Surveys are expected to follow the Through the Tide Count (TTC) method, but the exact survey method will be determined prior to commencement, in consultation with NatureScot.	To compare survey results with baseline data and determine if there are any changes in abundance and distribution of SPA qualifying species within Sectors 4 – 11.
HRA9	Construction phase	Plant and personnel will be constrained to a prescribed working corridor to minimise the damage to habitats and potential direct mortality and disturbance to birds located adjacent to the Scheme Site Boundary.	To avoid or reduce habitat loss and disturbance to qualifying features of the Firth of Forth SPA/Ramsar site.
HRA10	Construction phase	Where safe to do so, 2m noise and visual barrier screens will be installed prior to construction along the works areas adjacent to the estuary in front of the breakwater and sheltered bay. The barriers must be appropriately positioned to help reduce noise and visual disturbance and will remain in place for the duration of works in these areas.	To avoid or reduce noise and visual disturbance to qualifying features of the Firth of Forth SPA/Ramsar site.
HRA11	Construction phase	Within 300m of the Firth of Forth SPA, the ECoW will advise the contractor where a 'soft-start' to machinery is required to avoid sudden and unexpected disturbance during construction. Each time machinery is started up after a period of inactivity, the noise levels will be gradually increased over a period of 30 minutes to allow birds (and other animals) to relocate. This will apply year-round. For the first seven days after the commencement of works in each area, the soft-start must be applied each time the machinery is stopped, even if this is only for very short periods. Subject to ECoW assessment of bird responses to the activity, the duration of periods of inactivity requiring a soft-start will be increased incrementally over this seven-day period and after seven days a soft-start will only be required at the start of works each day or after an extended period of inactivity.	To avoid or reduce noise and vibration disturbance to qualifying features of the Firth of Forth SPA/Ramsar site.
HRA12	Construction/ Post-construction	On completion of the works all temporary access tracks and working platforms will be removed in their entirety from the SPA.	To ensure compliance with legislation and commitments within this HRA.
HRA13	Post-construction	The LEHMP will include measures to reduce damage and restore the intertidal areas temporarily lost. Post-construction monitoring will be undertaken, in accordance with the LEHMP, to demonstrate effectiveness of the restoration.	To ensure compliance with legislation and commitments within this HRA.

Table 4.18: Stage 2 Appropriate Assessment table of impacts for qualifying species

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
Bar-tailed godwit	Habitat Loss Bar-tailed godwit was not recorded under the permanent or temporary habitat loss footprint during surveys. The absence of the species under the footprint of the Scheme and records of bar-tailed godwit elsewhere within the survey areas suggests that the birds favour other areas within the Firth of Forth SPA/Ramsar site. Therefore, the area lost as a result of the Scheme is not functionally important supporting habitat for this species and no impacts on bar-tailed godwit are predicted in relation to habitat loss. The following conservation objectives will be maintained: to avoid the deterioration of habitats, ensure distribution of species within the site, and ensure distribution and extent of habitats supporting the species.	No mitigation is required: bar-tailed godwit was not recorded utilising habitat that will be temporarily unavailable or permanently altered as a result of the Scheme.	No potential for AESI
	Disturbance/Displacement (high tide roosts) Disturbance could result in disrupted roosting behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Bar-tailed godwit was recorded within the ZoI frequently at high tide. The primary areas of roosting were at the mouth of the River Avon, in Kinneil Lagoons and north of the petrochemical plant (sheltered bay). A peak count of 480 birds (24% of the cited SPA population) was recorded at high tide roosting north of the petrochemical plant. Bar-tailed godwit are sensitive to disturbance, especially at roost sites (Woodward et al., 2015). Given the large aggregations that roost at several hotspots within the ZoI, displacement due to noise and visual stimuli during construction is likely to occur, which could alter the distribution of the species within the site. Bar-tailed godwit roosts within 300m of works may be subject to disturbance and displacement during construction and also potentially during maintenance works, but only at high tide (i.e. for short periods). Disturbance is predicted to be localised, with birds potentially displaced to Bothkennar Pools and surrounding farmland and/or Kinneil Lagoons. Displacement outwith the SPA is not predicted given the availability of alternative roost sites within 1km of the Scheme, and therefore the population of the species as a viable component of the site will not be impacted.	Given the complexities and scale of the Scheme, the construction of the flood defences along the site cannot be exclusively undertaken outside of the wintering bird season (October – March inclusive). The following measures will be undertaken during construction in order to prevent disturbance impacts on important overwintering bird populations: • Any temporary lighting will be designed to ensure minimal light spill (HRA4). • Any works undertaken adjacent to the SPA within Flood Cells 3 and 6 will be undertaken independently of each other, with at least one winter in between (HRA5). • The ECoW will undertake or oversee a watching brief of works adjacent to the Firth of Forth SPA/Ramsar site (HRA7). • Plant and personnel will be constrained to a prescribed working corridor (HRA9). • Where safe to do so, visual and noise screening will be installed prior to construction along the works areas adjacent to the estuary in front of the breakwater and sheltered bay to screen the movement of vehicles, plant and site personnel from birds (HRA10). • The contractor will employ a 'soft-start' to noisy activities, as advised by the ECoW (HRA11).	Potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
		In addition to the avoidance and mitigation measures detailed above, the appointed ECoW will ensure these mitigation measures are implemented to avoid and reduce impacts on qualifying species. Monitoring surveys will also be undertaken by the employer's ecologist throughout construction to demonstrate the effectiveness of the mitigation.	
	<u>Disturbance/Displacement (foraging birds)</u> Disturbance could result in disrupted foraging behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Bar-tailed godwit was recorded foraging on multiple occasions within the ZoI, with most activity recorded in Sectors 9 and 10. A peak count of 360 birds (18% of the cited SPA population) was recorded at the mouth of the River Avon. Bar-tailed godwit utilise the intertidal sand and mudflats within the SPA to forage for their preferred prey of bivalves such as *Macoma balthica*, *Scrobicularia plana* and *Mya arenaria*. At some sites, polychaete worms form a larger proportion of the diet and the species is relatively adaptable, utilising other habitats for foraging where available, such as terrestrial grassland, coastal marshes and freshwater lagoons (Woodward et al., 2015). These birds are considered to have a high site fidelity, but small numbers will move sites within or between winters. As there is alternative suitable habitat within the estuary for bar-tailed godwit to feed, no impacts are predicted on foraging bar-tailed godwit, in relation to disturbance/displacement. The following conservation objectives will be maintained: ensure population of the species as a viable component of the site, ensure distribution of the species within the site, and no significant disturbance of the species.	No mitigation is required. However, mitigation measures that are proposed to prevent high tide roost disturbance impacts to bar-tailed godwit would remove impacts that could compromise the conservation objectives for foraging bar-tailed godwit.	No potential for AESI
Cormorant	<u>Habitat Loss</u> Construction of the Scheme will result in temporary habitat loss of up to 0.43ha within the SPA, (of which 0.25ha is mudflat habitat) and the permanent alteration of up to 1.15ha (of which 0.59ha is mudflat habitat). Cormorant was recorded under the temporary habitat loss footprint on four occasions during high and rising tides (peak count of 11 birds). Cormorant was also recorded within the wider survey area. They are widespread and common within the Firth of Forth and make use of structures such as buoys, breakwaters, walls and rocks when roosting. Given the low numbers recorded infrequently under the Scheme footprint, the habitats lost either temporarily or permanently as a result of the Scheme are not considered to be functionally important for cormorant, and no impacts on cormorant are predicted in relation to habitat loss.	No mitigation is required. However, to ensure that the conservation objectives for cormorant are not compromised, the following measures will be undertaken. The measures will prevent a change in the distribution of cormorant and will protect the structure and function of the habitats that support the species within the sites: • A LEHMP will be developed which will include measures to reduce damage and restore the intertidal areas temporarily lost. • Plant and personnel will be constrained to a prescribed working corridor. • On completion of works all access tracks and working platforms will be removed in their entirety from the SPA.	No potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
	The following conservation objectives will be maintained: to avoid the deterioration of habitats, ensure distribution of species within the site, and ensure distribution and extent of habitats supporting the species.	In addition to the avoidance and mitigation measures detailed above, an ECoW will be appointed who will ensure these mitigation measures are implemented to avoid and reduce impacts on qualifying species.	
	<u>Disturbance/Displacement (high tide roosts)</u> Disturbance could result in disrupted roosting behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Cormorant was recorded roosting most frequently within Sectors 6 and 7, making use of the breakwater and structures around the entrance to the Port of Grangemouth. The area that could potentially be disturbed by works would be proportionally small in comparison to the area these birds typically utilise. Cormorant tolerate high levels of human activity and the presence of artificial structures (McKay et al., 1999; Dierschke et al., 2016) so are less vulnerable to noise and visual disturbance. Given the high mobility, opportunistic use of a large number of different sites for roosting, and low sensitivity to human activity and artificial structures, it is highly unlikely that construction work associated with the Scheme would affect the natural patterns of movement and distribution of cormorant. No impacts on roosting cormorant are predicted in relation to disturbance/displacement. The following conservation objectives will be maintained: ensure population of the species as a viable component of the site, ensure distribution of the species within the site, and no significant disturbance of the species.	No mitigation is required. However, mitigation measures that are proposed to prevent high tide roost disturbance impacts to other qualifying species would remove impacts that could compromise the conservation objectives for roosting cormorant.	No potential for AESI
	<u>Disturbance/Displacement (foraging birds)</u> Disturbance could result in disrupted foraging behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Cormorant feed in open water and are highly mobile during the non-breeding season. Tracked individuals have been recorded making extensive journeys (up to 45km) between sites throughout Scotland depending on food availability (Forrester et al., 2007), moving not only between estuaries but also between coastal and inland feeding sites. Tracking identified that cormorant wintering on the Firth of Forth typically roost at Loch Leven but can forage in areas up to 50km from that site, including the Firth of Forth and many other sites (Wright, 2003). The habitat potentially disturbed would be proportionally small in comparison to the area these birds typically utilise. Given the high mobility, opportunistic use of a large number of different foraging areas (both within and outside of the SPA) and low sensitivity to human activity, it is unlikely that construction of the Scheme would affect the natural patterns of movement and distribution of cormorants.	No mitigation is required. However, mitigation measures that are proposed to prevent high tide roost disturbance impacts to other qualifying species would remove impacts that could compromise the conservation objectives for foraging cormorant.	No potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
	No impacts on foraging cormorant are predicted in relation to disturbance/displacement. The following conservation objectives will be maintained: ensure population of the species as a viable component of the site, ensure distribution of the species within the site, and no significant disturbance of the species.		
Curlew	<u>Habitat Loss</u> Curlew was not recorded under the permanent or temporary habitat loss footprint during surveys. The absence of the species during surveys suggests that there are other areas within the SPA/Ramsar site favoured by curlew during the winter, and that the area lost as a result of the Scheme is not functionally important supporting habitat for this species. No impacts on curlew are predicted in relation to habitat loss. The following conservation objectives will be maintained: to avoid the deterioration of habitats, ensure distribution of species within the site, and ensure distribution and extent of habitats supporting the species.	No mitigation is required: curlew was not recorded utilising habitat that will be temporarily unavailable or permanently altered as a result of the Scheme.	No potential for AESI
	<u>Disturbance/Displacement (high tide roosts)</u> Disturbance could result in disrupted roosting behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Curlew was recorded within the ZoI frequently at high tide. The primary areas of roosting were at the mouth of the River Avon, in Kinneil Lagoons and north of the petrochemical plant (sheltered bay). A peak count of 430 birds (22% of the cited SPA population) was recorded at high tide roosting in Kinneil Lagoons. Generally, curlew roost communally, usually along salt marshes and sand banks (Berg, 1993). Given the large aggregations that roost at several hotspots within the ZoI, displacement due to noise and visual stimuli during construction is likely to occur, which could alter the distribution of the species within the site. Disturbance and displacement of roosting birds within 650m of works is possible at high tide (i.e. for short periods) during construction and also potentially during maintenance works. Studies have indicated that curlew are wary of moderate and high-level visual disturbances and do not habituate to works quickly. They can be intolerant of people, allowing an approximate approach range of 120m-300m before flushing when confronted with a lone walker on a mudflat (Cutts et al., 2013). Curlew are considered to have a high site fidelity and are reliant on a site (intertidal mud and sandflats) but do utilise alternative habitats at certain times (e.g. during high tide). Any disturbance is predicted to be localised, potentially displacing birds to Bothkennar Pools and surrounding farmland and/or Kinneil Lagoons. Curlew utilise grassland surrounding the site for both foraging and roosting (MacArthur Green, 2017) outside of the ZoI: this area will not be impacted during construction works. Displacement outwith the SPA is not predicted given the availability of	Given the complexities and scale of the Scheme, the construction of the flood defences along the site cannot be exclusively undertaken outside of the wintering bird season (October – March inclusive). The following measures will be undertaken during construction in order to prevent disturbance impacts on important overwintering bird populations: • Any temporary lighting will be designed to ensure minimal light spill (HRA4). • Any works undertaken adjacent to the SPA within Flood Cells 3 and 6 will be undertaken independently of each other, with at least one winter in between (HRA5). • The ECoW will undertake or oversee a watching brief of works adjacent to the Firth of Forth SPA/Ramsar site (HRA7). • Plant and personnel will be constrained to a prescribed working corridor (HRA9). • Where safe to do so, visual and noise screening will be installed prior to construction along the works areas adjacent to the estuary in front of the breakwater and sheltered bay to screen the movement of vehicles, plant and site personnel from birds (HRA10). • The contractor will employ a 'soft-start' to noisy activities, as advised by the ECoW (HRA11).	Potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
	alternative roost sites within 1km of the Scheme and therefore the population of the species as a viable component of the site will not be impacted.	In addition to the avoidance and mitigation measures detailed above, the appointed ECoW will ensure these mitigation measures are implemented to avoid and reduce impacts on qualifying species. Monitoring surveys will also be undertaken by the employer's ecologist throughout construction to demonstrate the effectiveness of the mitigation.	
	<u>Disturbance/Displacement (foraging birds)</u> Disturbance could result in disrupted foraging behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Curlew was recorded within the ZoI foraging on multiple occasions, predominantly at the mouth of the River Avon and east of the petrochemical works. Curlew utilise the intertidal sand and mudflats within the SPA for foraging and also forage across grassland surrounding the site (MacArthur Green, 2017). Within intertidal areas they feed on larger prey items such as crabs, large worms and bivalves. Their de-curved bill is ideally suited to extracting deep-living worms such as lugworms (*Arenicola marina*). Curlew are also known to heavily utilise agricultural grassland as foraging sites, especially during periods of high tide. As curlew rely on large prey, this takes longer to extract and consume than the typically smaller prey of many other wader species. As a consequence, curlew are territorial foragers and individuals are usually well dispersed across the estuary while feeding (Berg, 1993) to avoid competitive conflicts. This foraging behaviour results in curlew being vulnerable to disturbances. Given their diet of larger prey, curlew is considered to have a high site fidelity and are reliant on a site (intertidal mud and sandflats) but do utilise alternative habitats at certain times (e.g. during high tide). Observed curlew reaction to disturbance events during construction of flood defences suggests that they have a minimum feeding range of 150m from works, which may reduce to 100m after habituation (Cutts and Allen, 1999). In another example, observation of two disturbed sites, one with highly disturbing works and one with moderately disturbing works, identified curlew foraging regularly within 100m. No reactions were observed to machinery operation. Given the considerable area of alternative foraging habitat in close proximity to the site, notably mudflats at Kinneil Kerse and Skinflats, and surrounding farmland, no impacts on foraging curlew are predicted in relation to disturbance/displacement. The following conservation objectives will be maintained: ensure population of the species as a viable component of the site, ensure distribution of the species within the site, and no significant disturbance of the species.	No mitigation is required. However, mitigation measures that are proposed to prevent high tide roost disturbance impacts to curlew would remove impacts that could compromise the conservation objectives for foraging curlew.	No potential for AESI
Dunlin	<u>Habitat Loss</u> Construction of the Scheme will result in temporary habitat loss of up to 0.43ha within the SPA, (of which 0.25ha is mudflat habitat) and the permanent alteration of up to 1.15ha (of which 0.59ha is	No mitigation is required. However, to ensure that the conservation objectives for dunlin are not compromised, the following measures will be undertaken. The measures will prevent a change in the distribution of	No potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
	mudflat habitat). Dunlin was recorded on five occasions under the permanent and temporary habitat loss footprint of the Scheme. A peak count of 8,000 birds (84% of the cited SPA population) was recorded in Sector 10 in 2016. Dunlin was the most abundant species recorded during the surveys with birds recorded across most of the study area through each tidal state. A study carried out by Conklin and Colwell (2007) looked at high tide roost fidelity of wintering dunlin. During the study, despite dunlin showing high fidelity to the study area, fidelity to particular roosts was relatively low and highly variable. At night, dunlin used fewer roosts, were more faithful to primary roosts, and moved shorter distances between successive roosts than during the day. Day and night roosts differed in location, habitat, and distance from tidal flats. The results of this study highlighted that unlike other species (e.g. curlew) dunlin do not exhibit the traditional roosting behaviour and are more sporadic moving between several roost sites. This is similar to the survey findings in that dunlin was observed to have a high fidelity to the study area and large flocks of dunlin (2,000 -11,000 birds) were recorded roosting across several different locations within this area. Although a large number of dunlin (8,000) was recorded on one occasion under the construction footprint for the Scheme, this individual record suggests that there are other areas within the SPA/Ramsar site utilised by dunlin during the winter and that the area under the footprint of the Scheme is not regular supporting habitat for this species. It is considered that the area of habitat lost would be negligible given the amount of remaining alternative roosting locations. In addition, the findings by Davies (2001) demonstrated that the benthic community of the upper shore around Grangemouth and Kinneil was less diverse and in lower abundances than the lower shore. The habitats lost either temporarily or permanently as a result of the Scheme are not considered to be functionally important for dunlin and no impacts on dunlin are predicted in relation to habitat loss. The following conservation objectives will be maintained: to avoid the deterioration of habitats, ensure distribution of species within the site, and ensure distribution and extent of habitats supporting the species.	dunlin and will protect the structure and function of the habitats that support the species within the sites: • A LEHMP will be developed which will include measures to reduce damage and restore the intertidal areas temporarily lost. • Plant and personnel will be constrained to a prescribed working corridor. • On completion of works all access tracks and working platforms will be removed in their entirety from the SPA. In addition to the avoidance and mitigation measures detailed above, an ECoW will be appointed who will ensure these mitigation measures are implemented to avoid and reduce impacts on qualifying species.	
	<u>Disturbance/Displacement (high tide roosts)</u> Disturbance could result in disrupted roosting behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Dunlin was the most abundant species recorded during the surveys, with birds recorded roosting across most of the ZoI through all tidal states. As with Conklin and Colwell's (2007) study, birds were recorded in large aggregations throughout the ZoI and there was no regular roost site – birds moved between several roost sites. The highest numbers were recorded along the breakwater west of the Port of Grangemouth, in the sheltered bay north of the petrochemical plant, at the mouth of	Given the complexities and scale of the Scheme, the construction of the flood defences along the site cannot be exclusively undertaken outside of the wintering bird season (October – March inclusive). The following measures will be undertaken during construction in order to prevent disturbance impacts on important overwintering bird populations: • Any temporary lighting will be designed to ensure minimal light spill (HRA4).	Potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
	the River Avon, and in Kinneil Lagoons east of the petrochemical plant where birds roosted at high tide. A peak count of 11,000 birds (115% of the cited SPA population) was recorded in January 2017 roosting at high tide in the sheltered bay. Although dunlin is relatively tolerant of disturbance, large aggregations of birds were recorded roosting throughout the ZoI. Displacement due to noise and visual stimuli during construction, and also potentially during maintenance works, could occur which could alter the distribution of the species within the site. Dunlin roosts within 300m of works may be subject to disturbance and displacement during works, but only at high tide (i.e. for short periods), as this is when fewest alternative roost sites are available. Disturbance is predicted to be localised, with birds potentially displaced to Bothkennar Pools and surrounding farmland and/or Kinneil Lagoons. Displacement out of the SPA is not predicted given the availability of alternative roost sites and therefore the population of the species as a viable component of the site will not be impacted.	• Any works undertaken adjacent to the SPA within Flood Cells 3 and 6 will be undertaken independently of each other, with at least one winter in between (HRA5). • The ECoW will undertake or oversee a watching brief of works adjacent to the Firth of Forth SPA/Ramsar site (HRA7). • Plant and personnel will be constrained to a prescribed working corridor (HRA9). • Where safe to do so, visual and noise screening will be installed prior to construction along the works areas adjacent to the estuary in front of the breakwater and sheltered bay to screen the movement of vehicles, plant and site personnel from birds (HRA10). • The contractor will employ a 'soft-start' to noisy activities, as advised by the ECoW (HRA11). In addition to the avoidance and mitigation measures detailed above, the appointed ECoW will ensure these mitigation measures are implemented to avoid and reduce impacts on qualifying species. Monitoring surveys will also be undertaken by the employer's ecologist throughout construction to demonstrate the effectiveness of the mitigation.	
	<u>Disturbance/Displacement (foraging birds)</u> Disturbance could result in disrupted foraging behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Dunlin was recorded foraging across the study area in large aggregations of birds. Surveys recorded birds moving with the tide, foraging and constantly on the move. Birds were also noted to feed extensively across mudflats to the north and northwest of the petrochemical plant outside of the ZoI. Dunlin is relatively tolerant of disturbances. Whilst there are large aggregations that forage throughout the ZoI, there is a considerable area of alternative foraging habitat in close proximity. Given the large area of alternative foraging habitat, notably mudflats at Kinneil Kerse and Skinflats, no impacts are predicted on foraging dunlin. The following conservation objectives will be maintained: ensure population of the species as a viable component of the site, ensure distribution of the species within the site, and no significant disturbance of the species.	No mitigation is required. However, mitigation measures that are proposed to prevent high tide roost disturbance impacts to other qualifying species would remove impacts that could compromise the conservation objectives for foraging dunlin.	No potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
Eider (650m visual ZoI)	Habitat Loss Eider was not recorded within the temporary or permanent habitat footprint of the Scheme. The absence of the species under the footprint of the Scheme and records of eider elsewhere within the survey areas suggests that the birds favour other areas within the Firth of Forth SPA/Ramsar site. Therefore, the area lost as a result of the Scheme is not functionally important supporting habitat for this species and no impacts on eider are predicted in relation to habitat loss. The following conservation objectives will be maintained: to avoid the deterioration of habitats, ensure distribution of species within the site, and ensure distribution and extent of habitats supporting the species.	No mitigation is required: eider was not recorded utilising habitat that will be temporarily unavailable or permanently altered as a result of the Scheme.	No potential for AESI
	Disturbance/Displacement (high tide roosts) Eider was recorded infrequently during the winter bird surveys and are mostly associated with the outer Forth rather than the inner Forth (Bryant, 1987; Forrester et al., 2007). There were infrequent records (4 records) of eider within the 650m ZoI for this species, with a peak count of 5 birds in October 2016. There were no records of eider within the 650m ZoI at high or rising tide during the 2022/23 surveys. As numbers nationally have remained relatively stable, declines in the Forth are thought to be attributable, at least partially, to site-specific pressures. However, given the low numbers of birds present within the ZoI, it is unlikely that the distribution or population size of eider within the site will be significantly affected by the works. No impacts are predicted on roosting eider. The following conservation objectives will be maintained: ensure population of the species as a viable component of the site, ensure distribution of the species within the site, and no significant disturbance of the species.	No mitigation is required. However, mitigation measures that are proposed to prevent high tide roost disturbance impacts to other qualifying species would remove impacts that could compromise the conservation objectives for roosting eider.	No potential for AESI
	Disturbance/Displacement (foraging birds) Disturbance could result in disrupted foraging behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Eider was recorded in low numbers on four occasions within the ZoI during the surveys. Birds were feeding and loafing in open water and therefore less prone to disturbance from onshore activities. Due to the low number of the observations, it is unlikely that the distribution or population size of eider within the site will be significantly affected by the works, and therefore no impacts on foraging eider are predicted. The following conservation objectives will be maintained: ensure population of the species as a viable component of the site, ensure distribution of the species within the site, and no significant disturbance of the species.	No mitigation is required. However, mitigation measures that are proposed to prevent high tide roost disturbance impacts to other qualifying species would remove impacts that could compromise the conservation objectives for foraging eider.	No potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
Golden plover (650m visual ZoI)	<u>Habitat Loss</u> Golden plover was not recorded under the permanent or temporary habitat loss footprint during surveys. The absence of the species during surveys suggests that there are other areas within the SPA/Ramsar site favoured by golden plover during the winter, and that the area lost as a result of the Scheme is not functionally important supporting habitat for this species. No impacts on golden plover are predicted in relation to habitat loss. The following conservation objectives will be maintained: to avoid the deterioration of habitats, ensure distribution of species within the site, and ensure distribution and extent of habitats supporting the species.	No mitigation is required: golden plover was not recorded utilising habitat that will be temporarily unavailable or permanently altered as a result of the Scheme.	No potential for AESI
	<u>Disturbance/Displacement (high tide roosts)</u> Disturbance could result in disrupted roosting behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Golden plover was recorded within the ZoI at high tide. The primary area for roosting birds was Kinneil Lagoons, with birds also roosting at the mouth of the River Avon and north of the petrochemical plant (sheltered bay). Birds were also recorded using Bothkennar Pools and the breakwater. A peak count of 436 birds (14.8% of the cited SPA population) was recorded at Kinneil Lagoons. Although golden plover exhibits more tolerance to disturbance than other waders (SNH, 2016b), disturbance and displacement of roosting birds is possible at high tide. Golden plover roosts within 300m of works may be subject to disturbance and displacement during construction and also potentially during maintenance works, but only at high tide (i.e. for short periods). Disturbance is predicted to be localised, with birds potentially displaced to Bothkennar Pools and surrounding farmland and/or Kinneil Lagoons. Displacement outwith the SPA is not predicted given the availability of alternative roost sites within 1km of the Scheme and therefore the population of the species as a viable component of the site will not be impacted.	Given the complexities and scale of the Scheme, the construction of the flood defences along the site cannot be exclusively undertaken outside of the wintering bird season (October – March inclusive). The following measures will be undertaken during construction in order to prevent disturbance impacts on important overwintering bird populations: • Any temporary lighting will be designed to ensure minimal light spill (HRA4). • Any works undertaken adjacent to the SPA within Flood Cells 3 and 6 will be undertaken independently of each other, with at least one winter in between (HRA5). • The ECoW will undertake or oversee a watching brief of works adjacent to the Firth of Forth SPA/Ramsar site (HRA7). • Plant and personnel will be constrained to a prescribed working corridor (HRA9). • Where safe to do so, visual and noise screening will be installed prior to construction along the works areas adjacent to the estuary in front of the breakwater and sheltered bay to screen the movement of vehicles, plant and site personnel from birds (HRA10). • The contractor will employ a 'soft-start' to noisy activities, as advised by the ECoW (HRA11). In addition to the avoidance and mitigation measures detailed above, the appointed ECoW will ensure these mitigation measures are implemented to avoid and reduce impacts on qualifying species. Monitoring surveys	Potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
		will also be undertaken by the employer's ecologist throughout construction to demonstrate the effectiveness of the mitigation.	
	Disturbance/Displacement (foraging birds) Disturbance could result in disrupted foraging behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Golden plover was recorded foraging on multiple occasions within the ZoI, predominantly at the mouth of the River Avon and north of the petrochemical plant (sheltered bay). The infrequent encounters of golden plover within the ZoI suggests that there are other areas within the SPA/Ramsar site favoured by golden plover during the winter, and that the area around the Scheme is not important supporting habitat for this species. It is therefore concluded that there will be no impacts are predicted on foraging golden plover, in relation to disturbance/displacement. The following conservation objectives will be maintained: ensure population of the species as a viable component of the site, ensure distribution of the species within the site, and no significant disturbance of the species.	No mitigation is required. However, mitigation measures that are proposed to prevent high tide roost disturbance impacts to roosting golden plover would remove impacts that could compromise the conservation objectives for foraging golden plover.	No potential for AESI
Goldeneye	Habitat Loss Goldeneye was not recorded under the permanent or temporary habitat loss footprint during surveys. Goldeneye is generally associated with open water habitats in the outer Forth during winter. The absence of the species during surveys suggests that there are other areas within the SPA/Ramsar site favoured by goldeneye during the winter, and that the area lost as a result of the Scheme is not functionally important supporting habitat for this species. No impacts on goldeneye are predicted in relation to habitat loss. The following conservation objectives will be maintained: to avoid the deterioration of habitats, ensure distribution of species within the site, and ensure distribution and extent of habitats supporting the species.	No mitigation is required: goldeneye was not recorded utilising habitat that will be temporarily unavailable or permanently altered as a result of the Scheme.	No potential for AESI
	Disturbance/ displacement (high tide roosts) Disturbance could result in disrupted roosting behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Goldeneye was recorded in low numbers during the winter bird surveys (peak count of 23 birds equates 0.8% of cited SPA population). Goldeneye are associated predominantly with the sub-tidal area and outer Forth and do not come ashore during the winter months (Bryant, 1987: Forrester et al., 2007). The declines in numbers of goldeneye on the Forth have been linked to improvements in sewage treatment, as feeding flocks were only recorded at outfalls where sewage continued to be discharged in large quantities (Campbell, 1984). The contrast between the declining site trend	No mitigation is required. However, mitigation measures that are proposed to prevent high tide roost disturbance impacts to other qualifying species would remove impacts that could compromise the conservation objectives for roosting goldeneye.	No potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
	and both the regional and British trends suggests that declining numbers are possibly due to site-specific pressures. It is therefore considered unlikely that goldeneye would be significantly affected by the Scheme and no impacts on roosting goldeneye in are predicted. The following conservation objectives will be maintained: ensure population of the species as a viable component of the site, ensure distribution of the species within the site, and no significant disturbance of the species.		
	<u>Disturbance/Displacement (foraging birds)</u> Disturbance could result in disrupted foraging behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Goldeneye was recorded within the ZoI during the surveys at the mouth of the River Avon in multiple survey months, with a peak count of 23 birds. Goldeneye were also recorded infrequently in small numbers in Sectors 5 and 6 (highest peak count of six birds). Birds were feeding and loafing in open water and therefore less prone to disturbance from onshore activities. Due to the low number of the observations, it is unlikely that the distribution or population size of goldeneye within the site will be significantly affected by the works, and therefore no impacts are predicted on foraging goldeneye in relation to disturbance/displacement. The following conservation objectives will be maintained: ensure population of the species as a viable component of the site, ensure distribution of the species within the site, and no significant disturbance of the species.	No mitigation is required. However, mitigation measures that are proposed to prevent high tide roost disturbance impacts to other qualifying species would remove impacts that could compromise the conservation objectives for foraging goldeneye.	No potential for AESI
Great crested grebe	<u>Habitat Loss, Disturbance/Displacement (high tide roosts and foraging birds)</u> Great crested grebe was not recorded under the permanent or temporary habitat loss footprint during surveys. No impacts are predicted in relation to habitat loss. Great crested grebe was not recorded roosting within the ZoI and is unlikely to be significantly disturbed as this species predominantly relies on open water habitats (SNH, 2016b) outwith the ZoI. No impacts are predicted in relation to disturbance of high tide roosts. Great crested grebe was recorded foraging infrequently within the ZoI during the surveys, primarily to the east and northeast of the Scheme in open water near Kinneil Kerse during high tides. A peak count of 11 birds (1.5% of the cited SPA population) was recorded foraging northeast of the Port of Grangemouth in November 2016. Great crested grebe do not rely on any specific foraging habitat within the ZoI, as they are open water feeders which predominantly feed on fish, insects, crustaceans and molluscs and so there is an abundance of nearby suitable habitat. No impacts are predicted in relation to disturbance of foraging birds.	No mitigation is required: great crested grebe was not recorded utilising habitat that will be temporarily unavailable or permanently altered as a result of the Scheme and was also not recorded roosting within the ZoI. Foraging great crested grebe was also recorded infrequently within the ZoI. Mitigation measures that are proposed to prevent high tide roost disturbance impacts to other qualifying species would remove impacts that could compromise the conservation objectives for foraging and roosting great crested grebe.	No potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
	The following conservation objectives will be maintained: to avoid the deterioration of habitats, ensure population of the species as a viable component of the site, ensure distribution of the species within the site, and no significant disturbance of the species.		
Grey plover	Habitat Loss, Disturbance/Displacement (high tide roosts and foraging birds) Grey plover was not recorded under the permanent or temporary habitat loss footprint during surveys. No impacts are predicted in relation to habitat loss. Grey plover was recorded roosting within the ZoI during the surveys on two occasions with a peak count of 7 birds (1% of the cited SPA population). The declining trend in the SPA appears to be tracking the Scottish trend, however there is some evidence that the distribution of this species is shifting north-eastwards in response to climate change (Woodward et al., 2015). No impacts are predicted in relation to disturbance of high tide roosts. Grey plover was recorded foraging within the ZoI on multiple occasions at all tidal states in Sectors 4, 9 and 12. Grey plover feed intertidally on worms, molluscs and crustaceans in mudflats, of which there is an abundance of within the ZoI. No impacts are predicted in relation to disturbance of foraging grey plover. The following conservation objectives will be maintained: to avoid the deterioration of habitats, ensure population of the species as a viable component of the site, ensure distribution of the species within the site, and no significant disturbance of the species.	No mitigation is required: grey plover was not recorded utilising habitat that will be temporarily unavailable or permanently altered as a result of the Scheme. Grey plover was recorded roosting infrequently within the ZoI, and there is ample suitable habitat for foraging grey plover. Mitigation measures that are proposed to prevent high tide roost disturbance impacts to other qualifying species would remove impacts that could compromise the conservation objectives for foraging and roosting grey plover.	No potential for AESI
Knot	Habitat Loss Construction of the Scheme will result in temporary habitat loss of up to 0.43ha within the SPA, (of which 0.25ha is mudflat habitat) and the permanent alteration of up to 1.15ha (of which 0.59ha is	No mitigation is required. However, to ensure that the conservation objectives for knot are not compromised, the following measures will be undertaken. The measures will prevent a change in the distribution of	No potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
	mudflat habitat). Knot was recorded only once roosting within the temporary habitat loss footprint (in 2015) and no records fall within habitat that will be permanently altered. The main roosting sites for knot are located at the mouth of the River Avon and north of the petrochemical plant (sheltered bay) outwith the habitat loss areas. The survey data identifies that the habitat within the Scheme boundary is not a regular roost site for knot and it is considered that the area of habitat lost would be negligible given the amount of remaining alternative roosting locations. The areas of temporary and permanent habitat loss as a result of the Scheme are not considered to be functionally important for knot and no impacts are predicted in relation to habitat loss. The following conservation objectives will be maintained: to avoid the deterioration of habitats, ensure distribution of species within the site, and ensure distribution and extent of habitats supporting the species.	knot and will protect the structure and function of the habitats that support the species within the sites: • A LEHMP will be developed which will include measures to reduce damage and restore the intertidal areas temporarily lost. • Plant and personnel will be constrained to a prescribed working corridor. • On completion of works all access tracks and working platforms will be removed in their entirety from the SPA. In addition to the avoidance and mitigation measures detailed above, an ECoW will be appointed who will ensure these mitigation measures are implemented to avoid and reduce impacts on qualifying species.	
	<u>Disturbance/Displacement (high tide roosts)</u> Disturbance could result in disrupted roosting behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Knot was recorded within the ZoI frequently at high tide. Knot are sensitive to disturbance, especially at roost sites (Woodward et al., 2015). Although Pienkowski and Clark (1979) state that knot exhibit little site fidelity during the winter months, the data suggests that the ZoI is an important area for roosting knot as large aggregations of birds were recorded roosting at several locations. The primary areas of roosting were at the mouth of the River Avon, in Kinneil Lagoons and north of the petrochemical plant (sheltered bay). A peak count of 7,300 birds (78.9% of the cited SPA population) was recorded at high tide roosting at the mouth of the River Avon. Knot roosts within 300m of works may be subject to disturbance and displacement during construction, and also potentially during maintenance works, but only at high tide (i.e. for short periods). Disturbance is predicted to be localised, with birds potentially displaced to Bothkennar Pools and surrounding farmland and/or Kinneil Lagoons. Displacement outwith the SPA is not predicted given the availability of alternative roost sites within 1km of the Scheme and therefore the population of the species as a viable component of the site will not be impacted.	Given the complexities and scale of the Scheme, the construction of the flood defences along the site cannot be exclusively undertaken outside of the wintering bird season (October – March inclusive). The following measures will be undertaken during construction in order to prevent disturbance impacts on important overwintering bird populations: • Any temporary lighting will be designed to ensure minimal light spill (HRA4). • Any works undertaken adjacent to the SPA within Flood Cells 3 and 6 will be undertaken independently of each other, with at least one winter in between (HRA5). • The ECoW will undertake or oversee a watching brief of works adjacent to the Firth of Forth SPA/Ramsar site (HRA7). • Plant and personnel will be constrained to a prescribed working corridor (HRA9). • Where safe to do so, visual and noise screening will be installed prior to construction along the works areas adjacent to the estuary in front of the breakwater and sheltered bay to screen the movement of vehicles, plant and site personnel from birds (HRA10). • The contractor will employ a 'soft-start' to noisy activities, as advised by the ECoW (HRA11).	Potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
		In addition to the avoidance and mitigation measures detailed above, the appointed ECoW will ensure these mitigation measures are implemented to avoid and reduce impacts on qualifying species. Monitoring surveys will also be undertaken by the employer's ecologist throughout construction to demonstrate the effectiveness of the mitigation.	
	<u>Disturbance/Displacement (foraging birds)</u> Disturbance could result in disrupted foraging behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Knot was recorded on nine occasions within the ZoI foraging during low tides with a low tide peak count of 3,700 birds (39% of the cited SPA population) recorded east of the Port of Grangemouth in the mouth of the River Avon. Knot feed in very large flocks on open mudflats feeding on mainly molluscs, including tellins (*Macoma balthica*), mussels (*Mytilus edulis*), cockles (*Cerastoderma edulis*) and mudsnails, the latter especially in early winter. Flocks will move with the tide and may cover very extensive areas of mudflat (Woodward et al., 2015). Knot carry out widespread movements within the Forth Estuary and exhibit little site fidelity during the winter months (Pienkowski and Clark, 1979). Given the infrequent occurrences (but occasional large flocks in Sectors 9 and 10) of knot foraging within the ZoI during the surveys and the alternative foraging habitat located around Skinflats and Kinneil Lagoons, no impacts are predicted on foraging knot, relation to disturbance/displacement. The following conservation objectives will be maintained: ensure population of the species as a viable component of the site, ensure distribution of the species within the site, and no significant disturbance of the species.	No mitigation is required. However, mitigation measures that are proposed to prevent high tide roost disturbance impacts to other qualifying species would remove impacts that could compromise the conservation objectives for foraging knot.	No potential for AESI
Lapwing	<u>Habitat Loss</u> Construction of the Scheme will result in temporary habitat loss of up to 0.43ha within the SPA, (of which 0.25ha is mudflat habitat) and the permanent alteration of up to 1.15ha (of which 0.59ha is mudflat habitat). Lapwing was recorded only twice roosting within the permanent habitat loss footprint, in March 2016 and January 2017. Lapwing utilise pasture, wet meadows, saltmarsh, estuaries and arable farmland in winter for roosting and foraging. The survey data indicates that the area within the work footprint is not an important regular roost site for lapwing and it is considered that the area of habitat lost would be negligible given the amount of remaining alternative roosting locations. The areas of temporary and permanent habitat loss as a result of the Scheme are not considered to be functionally important for lapwing and no impacts are predicted in relation to habitat loss. The following conservation objectives will be maintained: to avoid the deterioration of habitats, ensure	No mitigation is required. However, to ensure that the conservation objectives for lapwing are not compromised, the following measures will be undertaken. The measures will prevent a change in the distribution of lapwing and will protect the structure and function of the habitats that support the species within the sites: • A LEHMP will be developed which will include measures to reduce damage and restore the intertidal areas temporarily lost. • Plant and personnel will be constrained to a prescribed working corridor. • On completion of works all access tracks and working platforms will be removed in their entirety from the SPA.	No potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
	distribution of species within the site and ensure distribution and extent of habitats supporting the species.	In addition to the avoidance and mitigation measures detailed above, an ECoW will be appointed who will ensure these mitigation measures are implemented to avoid and reduce impacts on qualifying species.	
	<u>Disturbance/ displacement (high tide roosts)</u> Disturbance could result in disrupted roosting behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Lapwing was recorded within the ZoI frequently at high tide, along the moving tideline and nearby fields, however numbers varied throughout the survey area over the two years. Lapwing was absent from Sectors 4, 7 and 8, with only three records in Sector 5 during the winter months. The primary areas of roosting were at the southern end of the breakwater, at the mouth of the River Avon and in Kinneil Lagoons. A peak count of 750 birds (18% of the cited SPA population) was recorded at rising tide roosting within Kinneil Lagoons. Given the large aggregations that roost at several hotspots within the ZoI, displacement due to noise and visual stimuli during works is likely to occur, which could alter the distribution of the species within the site. Lapwing roosts within 300m of works may be subject to disturbance and displacement during the construction period and also potentially during maintenance works, but only at high tide (i.e. for short periods). Disturbance is predicted to be localised, with birds potentially displaced to Bothkennar Pools and surrounding farmland and/or Kinneil Lagoons. Displacement outwith the SPA is not predicted given the availability of alternative roost sites within 1km of the Scheme and therefore the population of the species as a viable component of the site will not be impacted.	Given the complexities and scale of the Scheme, the construction of the flood defences along the site cannot be exclusively undertaken outside of the wintering bird season (October – March inclusive). The following measures will be undertaken during construction in order to prevent disturbance impacts on important overwintering bird populations: • Any temporary lighting will be designed to ensure minimal light spill (HRA4). • Any works undertaken adjacent to the SPA within Flood Cells 3 and 6 will be undertaken independently of each other, with at least one winter in between (HRA5). • The ECoW will undertake or oversee a watching brief of works adjacent to the Firth of Forth SPA/Ramsar site (HRA7). • Plant and personnel will be constrained to a prescribed working corridor (HRA9). • Where safe to do so, visual and noise screening will be installed prior to construction along the works areas adjacent to the estuary in front of the breakwater and sheltered bay to screen the movement of vehicles, plant and site personnel from birds (HRA10). • The contractor will employ a 'soft-start' to noisy activities, as advised by the ECoW (HRA11). In addition to the avoidance and mitigation measures detailed above, the appointed ECoW will ensure these mitigation measures are implemented to avoid and reduce impacts on qualifying species. Monitoring surveys will also be undertaken by the employer's ecologist throughout construction to demonstrate the effectiveness of the mitigation.	Potential for AESI
	<u>Disturbance/Displacement (foraging birds)</u> Disturbance could result in disrupted foraging behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival.	No mitigation is required. However, mitigation measures that are proposed to prevent high tide roost disturbance impacts for roosting lapwing would remove with the potential to compromise the conservation objectives for foraging lapwing.	No potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
	Lapwing was recorded within the ZoI foraging on multiple occasions, predominantly to the south of the breakwater and at the mouth of the River Avon. Lapwing utilise farmland for foraging; arable fields adjacent to the Scheme and outside of the ZoI will be unaffected by the construction. These areas, along with the considerable area of alternative foraging habitat in the estuary, will act as a refuge for displaced birds. It is therefore concluded that there will be no predicted impacts on foraging lapwing. The following conservation objectives will be maintained: ensure population of the species as a viable component of the site, ensure distribution of the species within the site, and no significant disturbance of the species.		
Mallard	<u>Habitat Loss</u> Construction of the Scheme will result in temporary habitat loss of up to 0.43ha within the SPA, (of which 0.25ha is mudflat habitat) and the permanent alteration of up to 1.15ha (of which 0.59ha is mudflat habitat). Mallard was recorded seven times within the temporary habitat loss footprint during the surveys, with a peak count of 20. Therefore, it is considered that the habitats lost either temporarily or permanently as a result of the Scheme are not functionally important for mallard, and no impacts are predicted in relation to habitat loss. The following conservation objectives will be maintained: to avoid the deterioration of habitats, ensure distribution of species within the site, and ensure distribution and extent of habitats supporting the species.	No mitigation is required. However, to ensure that the conservation objectives for mallard are not compromised, the following measures will be undertaken. The measures will prevent a change in the distribution of mallard and will protect the structure and function of the habitats that support the species within the sites: • A LEHMP will be developed which will include measures to reduce damage and restore the intertidal areas temporarily lost. • Plant and personnel will be constrained to a prescribed working corridor. • On completion of works all access tracks and working platforms will be removed in their entirety from the SPA. In addition to the avoidance and mitigation measures detailed above, an ECoW will be appointed who will ensure these mitigation measures are implemented to avoid and reduce impacts on qualifying species.	No potential for AESI
	<u>Disturbance/Displacement (high tide roosts)</u> Disturbance could result in disrupted roosting behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Mallard was recorded roosting throughout the ZoI at high tide in all survey Sectors except for Sector 4 throughout the survey period. A peak count of 180 birds (7% of the cited SPA population) was recorded north of the Port of Grangemouth. Given the moderate aggregations that roost at several hotspots within the ZoI, displacement due to noise and visual stimuli during works is possible at high tide, which could alter the distribution of the species within the site. Although mallard is relatively tolerant of moderate and high-level visual disturbance and will habituate rapidly to activity (Cutts, et al., 2013) disturbance and displacement of roosting birds during construction, and potentially during maintenance works, could occur at high tide. Mallard	Given the complexities and scale of the Scheme, the construction of the flood defences along the site cannot be exclusively undertaken outside of the wintering bird season (October – March inclusive). The following measures will be undertaken during construction in order to prevent disturbance impacts on important overwintering bird populations: • Any temporary lighting will be designed to ensure minimal light spill (HRA4). • Any works undertaken adjacent to the SPA within Flood Cells 3 and 6 will be undertaken independently of each other, with at least one winter in between (HRA5).	Potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
	roosts within 300m of works may be subject to disturbance and displacement during works but only at high tide (i.e. for short periods). Disturbance is predicted to be localised, with birds potentially displaced to Bothkennar Pools and surrounding farmland and/or Kinneil Lagoons. Displacement outwith the SPA is not predicted given the availability of alternative roost sites within 1km of the Scheme and therefore the population of the species as a viable component of the site will not be impacted.	• The ECoW will undertake or oversee a watching brief of works adjacent to the Firth of Forth SPA/Ramsar site (HRA7). • Plant and personnel will be constrained to a prescribed working corridor (HRA9). • Where safe to do so, visual and noise screening will be installed prior to construction along the works areas adjacent to the estuary in front of the breakwater and sheltered bay to screen the movement of vehicles, plant and site personnel from birds (HRA10). • The contractor will employ a 'soft-start' to noisy activities, as advised by the ECoW (HRA11). In addition to the avoidance and mitigation measures detailed above, the appointed ECoW will ensure these mitigation measures are implemented to avoid and reduce impacts on qualifying species. Monitoring surveys will also be undertaken by the employer's ecologist throughout construction to demonstrate the effectiveness of the mitigation.	
	<u>Disturbance/Displacement (foraging birds)</u> Disturbance could result in disrupted foraging behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Mallard was recorded foraging within the ZoI often during surveys, particularly around Sectors 8, 9 and 10. Mallard is omnivorous and an opportunistic feeder, consuming seeds and vegetative parts of aquatic plants, and variable amounts of terrestrial and aquatic invertebrates. Given the considerable area of alternative foraging habitat in close proximity to the site, notably the mudflats at Kinneil Kerse and Skinflats, no impacts are predicted on foraging mallard. The following conservation objectives will be maintained: ensure population of the species as a viable component of the site, ensure distribution of the species within the site, and no significant disturbance of the species.	No mitigation is required. However, mitigation measures that are proposed to prevent high tide roost disturbance impacts to mallard would remove impacts that could compromise the conservation objectives for foraging mallard.	No potential for AESI
Oystercatcher	<u>Habitat Loss</u> Construction of the Scheme will result in temporary habitat loss of up to 0.43ha within the SPA, (of which 0.25ha is mudflat habitat) and the permanent alteration of up to 1.15ha (of which 0.59ha is mudflat habitat). Oystercatcher was not recorded under the permanently altered habitat or habitat unavailable during construction during the surveys.	No mitigation is required. However, to ensure that the conservation objectives for oystercatcher are not compromised, the following measures will be undertaken. The measures will prevent a change in the distribution of oystercatcher and will protect the structure and function of the habitats that support the species within the sites: • A LEHMP will be developed which will include measures to reduce damage and restore the intertidal areas temporarily lost.	No potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
	The survey data indicates that the area within the work footprint is not an important regular roost site for oystercatcher and it is considered that the area of habitat lost would be negligible given the amount of remaining alternative roosting locations. The habitats lost either temporarily or permanently as a result of the Scheme are not considered to be functionally important for oystercatcher and no impacts are predicted in relation to habitat loss. The following conservation objectives will be maintained: to avoid the deterioration of habitats, ensure distribution of species within the site and ensure distribution, and extent of habitats supporting the species.	• Plant and personnel will be constrained to a prescribed working corridor. • On completion of works all access tracks and working platforms will be removed in their entirety from the SPA. In addition to the avoidance and mitigation measures detailed above, an ECoW will be appointed who will ensure these mitigation measures are implemented to avoid and reduce impacts on qualifying species.	
	<u>Disturbance/Displacement (high tide roosts)</u> Disturbance could result in disrupted roosting behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Oystercatcher was recorded within the ZoI at rising/high tide. The primary area for roosting birds was along the breakwater, at the mouth of the River Avon and north of the petrochemical plant (sheltered bay). A peak count of 588 birds (7.5% of the cited SPA population) was recorded roosting north of the petrochemical plant. Large aggregations were recorded moving out of the ZoI at high tide, however several roosting hotspots were still evident. Given the large aggregations that roost at several hotspots within the ZoI, displacement as a result from noise and visual stimuli during works is possible at high tide, which could impact on the distribution of the species within the site. Although oystercatcher is relatively tolerant to disturbance, the potential for displacement of roosting birds is still predicted at high tide. Roosts within 300m of works may be subject to disturbance and displacement throughout the construction and also potentially during maintenance works, but only at high tide (i.e. for short periods). Disturbance is predicted to be localised, with birds potentially displaced to Bothkennar Pools and surrounding farmland and/or Kinneil Lagoons. Displacement outwith the SPA is not predicted given the availability of alternative roost sites within 1km of the Scheme and therefore the population of the species as a viable component of the site will not be impacted.	Given the complexities and scale of the Scheme, the construction of the flood defences along the site cannot be exclusively undertaken outside of the wintering bird season (October – March inclusive). The following measures will be undertaken during construction in order to prevent disturbance impacts on important overwintering bird populations: • Any temporary lighting will be designed to ensure minimal light spill (HRA4). • Any works undertaken adjacent to the SPA within Flood Cells 3 and 6 will be undertaken independently of each other, with at least one winter in between (HRA5). • The ECoW will undertake or oversee a watching brief of works adjacent to the Firth of Forth SPA/Ramsar site (HRA7). • Plant and personnel will be constrained to a prescribed working corridor (HRA9). • Where safe to do so, visual and noise screening will be installed prior to construction along the works areas adjacent to the estuary in front of the breakwater and sheltered bay to screen the movement of vehicles, plant and site personnel from birds (HRA10). • The contractor will employ a 'soft-start' to noisy activities, as advised by the ECoW (HRA11). In addition to the avoidance and mitigation measures detailed above, the appointed ECoW will ensure these mitigation measures are implemented to avoid and reduce impacts on qualifying species. Monitoring surveys	Potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
		will also be undertaken by the employer's ecologist throughout construction to demonstrate the effectiveness of the mitigation.	
	<u>Disturbance/Displacement (foraging birds)</u> Disturbance could result in disrupted foraging behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Oystercatcher was recorded within the ZoI foraging on multiple occasions throughout the survey period. Oystercatchers are tolerant to disturbance and can habituate to ongoing activity. As birds are likely to habituate to disturbance and any birds which are displaced are likely to be able to re-distribute to other suitable foraging locations within 1km, no impacts on foraging oystercatcher are predicted. The following conservation objectives will be maintained: ensure population of the species as a viable component of the site, ensure distribution of the species within the site, and no significant disturbance of the species.	No mitigation is required. However, mitigation measures that are proposed to prevent high tide roost disturbance impacts to oystercatcher would remove impacts that could compromise the conservation objectives for foraging oystercatcher.	No potential for AESI
Pink footed goose (650m visual ZoI)	<u>Habitat Loss, Disturbance/Displacement (high tide roosts and foraging birds)</u> Pink footed goose was not recorded under the permanent or temporary habitat loss footprint during surveys. No impacts in relation to habitat loss are predicted. Disturbance could result in disrupted foraging/roosting behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Pink footed goose was recorded on the edge of the ZoI roosting or foraging in Sector 4 with a peak count of 1,370 birds, on the boundary of Bothkennar Pools and mudflats, with other peak count records ranging from 1 - 600 birds throughout Sectors 4, 5, 6, and 7. Pink footed goose utilise fields surrounding the site for foraging and are influenced by the cropping regime and changes throughout the winter in response to food availability. They will feed on a variety of crops including stubble fields, potato remains, beet remains, grass, and winter-sown cereals. Research has shown that there can be a preference for stubble fields in the autumn and early winter and grassland later in the winter (Mitchell, 2012). Pink footed goose will roost overnight on open water within the estuary or open water (such as Bothkennar Pools or Kinneil Lagoons), or they will roost in large open agricultural spaces such as the fields to the south of Sector 4. There are multiple areas of suitable habitat for roosting pink footed goose adjacent to the ZoI. No impacts are predicted in relation to disturbance of foraging or roosting birds. The infrequent encounters of pink footed goose within the ZoI suggests that there are other areas within the SPA/Ramsar site that are favoured during the winter for roosting and foraging. Therefore, it is considered that the ZoI does not contain important supporting habitat for this species and no impacts on pink footed goose are predicted. The following conservation objectives	No mitigation is required: pink-footed goose was not recorded utilising habitat that will be temporarily unavailable or permanently altered as a result of the Scheme and was recorded infrequently within the 650m ZoI. Mitigation measures that are proposed to prevent high tide roost disturbance impacts to other qualifying species would remove impacts that could compromise the conservation objectives for foraging and roosting pink-footed goose.	No potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
	will be maintained: ensure population of the species as a viable component of the site, ensure distribution of the species within the site, and no significant disturbance of the species.		
Red-breasted merganser	Habitat Loss Red-breasted merganser was not recorded under the permanent or temporary habitat loss footprint during surveys. The absence of the species during surveys suggests that there are other areas within the SPA/Ramsar site favoured by red-breasted merganser during the winter, and that the area lost as a result of the Scheme is not functionally important supporting habitat for this species. No impacts on red-breasted merganser are predicted in relation to habitat loss. The following conservation objectives will be maintained: to avoid the deterioration of habitats, ensure distribution of species within the site and ensure distribution and extent of habitats supporting the species.	No mitigation is required: red-breasted merganser was not recorded utilising habitat that will be temporarily unavailable or permanently altered as a result of the Scheme.	No potential for AESI
	Disturbance/Displacement (high tide roosts) Disturbance could result in disrupted roosting behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Red-breasted merganser was recorded at high tide predominantly near the breakwater, north-east of the Port of Grangemouth and at the mouth of the River Avon. Red-breasted merganser are associated with the sub-tidal area of the Firth of Forth and rarely come ashore during the winter months and hence are not sensitive to increased activity from development from land (Gillingwater, 2018). Therefore, this species is unlikely to be significantly disturbed and/or deterred from the area as a result of the Scheme and they are predicted to readily redistribute within their natural range in the Firth of Forth. Therefore, no impacts on roosting red-breasted merganser are predicted. The following conservation objectives will be maintained: ensure population of the species as a viable component of the site, ensure the distribution of the species within the site, and no significant disturbance of the species.	No mitigation is required. However, mitigation measures that are proposed to prevent high tide roost disturbance impacts to other qualifying species would remove impacts that could compromise the conservation objectives for roosting red-breasted merganser.	No potential for AESI
	Disturbance/Displacement (foraging birds) Disturbance could result in disrupted foraging behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Red-breasted merganser was recorded at high tide predominantly near the breakwater, north-east of the Port of Grangemouth and at the mouth of the River Avon. Red-breasted merganser are associated with the sub-tidal area of the Firth of Forth and rarely come ashore during the winter months and hence are not sensitive to increased activity from development from land (Gillingwater, 2018). Therefore, this species is unlikely to be significantly disturbed and/or deterred from the area as a result of the Scheme and they are predicted to readily redistribute	No mitigation is required. However, mitigation measures that are proposed to prevent high tide roost disturbance impacts to other qualifying species would remove impacts that could compromise the conservation objectives for foraging red-breasted merganser.	

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
	within their natural range in the Firth of Forth. Therefore, no impacts on foraging red-breasted merganser are predicted. The following conservation objectives will be maintained: ensure population of the species as a viable component of the site, ensure the distribution of the species within the site and no significant disturbance of the species.		
Red-throated diver (650m visual ZoI)	<u>Habitat Loss</u> Red-throated diver was not recorded under the permanent or temporary habitat loss footprint during surveys. Red-throated diver is generally associated with open water habitats in the outer Forth during winter. The absence of the species during surveys suggests that there are other areas within the SPA/Ramsar site favoured by red-throated diver during the winter, and that the area lost as a result of the Scheme is not functionally important supporting habitat for this species. No impacts on red-throated diver are predicted in relation to habitat loss. The following conservation objectives will be maintained: to avoid the deterioration of habitats, ensure distribution of species within the site, and ensure distribution and extent of habitats supporting the species.	No mitigation is required: red-throated diver was not recorded utilising habitat that will be temporarily unavailable or permanently altered as a result of the Scheme.	No potential for AESI
	<u>Disturbance/ displacement (high tide roosts)</u> Disturbance could result in disrupted roosting behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Red-throated diver was recorded in Sector 7 only and in low numbers during the winter bird surveys, with one record of two birds in both November 2016 and November 2022 and one record of one bird in December 2022. Red-throated diver are associated predominantly with the sub-tidal area and outer forth and do not come ashore during the winter months (Lack, 1986). The contrast between the declining site trend and both the regional and British trends suggests that declining numbers are possibly due to site-specific pressures. It is therefore considered unlikely that red-throated diver would be significantly affected by the Scheme and no disturbance/displacement impacts on foraging red-throated diver are predicted. The following conservation objectives will be maintained: ensure population of the species as a viable component of the site, ensure distribution of species within the site, and ensure distribution and extent of habitats supporting the species.	No mitigation is required. However, mitigation measures that are proposed to prevent high tide roost disturbance impacts to other qualifying species would remove impacts that could compromise the conservation objectives for roosting red-throated diver.	No potential for AESI
	<u>Disturbance/Displacement (foraging birds)</u> Disturbance could result in disrupted foraging behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Red-throated diver were only recorded within Sector 7 during the surveys on three occasions, and red-throated diver are associated with the sub-tidal area and outer forth. Birds were feeding and	No mitigation is required. However, mitigation measures that are proposed to prevent high tide roost disturbance impacts to other qualifying species would remove impacts that could compromise the conservation objectives for foraging red-throated diver.	No potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
	loafing in open water and therefore less prone to disturbance from onshore activities. Due to the low number of the observations, it is unlikely that the distribution or population size of red-throated diver within the site will be significantly affected by the works, and therefore no impacts on foraging red-throated diver are predicted. The following conservation objectives will be maintained: to avoid the deterioration of habitats, ensure distribution of species within the site, and ensure distribution and extent of habitats supporting the species.		
Redshank	<u>Habitat Loss</u> Construction of the Scheme will result in temporary habitat loss of up to 0.43ha within the SPA, (of which 0.25ha is mudflat habitat) and the permanent alteration of up to 1.15ha (of which 0.59ha is mudflat habitat). Some potentially suitable high tide roost habitat would be lost. However, surveys have shown few instances of roosting birds in this location; during the two years of survey data, with 12 records with a peak count of 266 birds (6% of SPA population) roosting within the permanently altered habitat along the upper shoreline east of the petrochemical plant. In addition, there are six records with a peak count of 114 birds (2% of cited SPA population) of redshank recorded under the habitat that will be unavailable during construction. It is considered that the area of habitat lost would be negligible given the amount of remaining alternative roosting locations for redshank along the extent of the shoreline north of the petrochemical plant (sheltered bay) and south to Kinneil Lagoons. The habitats lost either temporarily or permanently as a result of the Scheme are not considered to be functionally important for redshank and no impacts are predicted in relation to habitat loss. The following conservation objectives will be maintained: to avoid the deterioration of habitats, ensure distribution of species within the site, and ensure distribution and extent of habitats supporting the species.	No mitigation is required. However, to ensure that the conservation objectives for redshank are not compromised, the following measures will be undertaken. The measures will prevent a change in the distribution of redshank and will protect the structure and function of the habitats that support the species within the sites: • A LEHMP will be developed which will include measures to reduce damage and restore the intertidal areas temporarily lost. • Plant and personnel will be constrained to a prescribed working corridor. • On completion of works all access tracks and working platforms will be removed in their entirety from the SPA. In addition to the avoidance and mitigation measures detailed above, an ECoW will be appointed who will ensure these mitigation measures are implemented to avoid and reduce impacts on qualifying species.	No potential for AESI
	<u>Disturbance/Displacement (high tide roosts)</u> Disturbance could result in disrupted roosting behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Large aggregations of roosting redshank occur throughout the winter at high tide in Sectors 6, 7, 8, 9 and 10. Occurrences of redshank were much lower in Sectors 5 and 11 with the species virtually absent in Sector 4 during the winter months. Given the large aggregations that roost at several hotspots within the ZoI, displacement as a result from noise and visual stimuli during construction is likely to occur, impacting on the distribution of the species within the site. Redshank roosts within 300m of works may be subject to disturbance and displacement during the construction and also potentially during maintenance works, but only at high tide (i.e. for short periods). Disturbance is predicted to be localised, with birds potentially displaced to Bothkennar	Given the complexities and scale of the Scheme, the construction of the flood defences along the site cannot be exclusively undertaken outside of the wintering bird season (October – March inclusive). The following measures will be undertaken during construction in order to prevent disturbance impacts on important overwintering bird populations: • Any temporary lighting will be designed to ensure minimal light spill (HRA4). • Any works undertaken adjacent to the SPA within Flood Cells 3 and 6 will be undertaken independently of each other, with at least one winter in between (HRA5).	Potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
	Pools (from Sectors 6 and 7) and surrounding farmland and/or Kinneil Lagoons (from Sectors 8 to 11). Displacement outwith the SPA is not predicted given the availability of alternative roost sites and therefore the population of the species as a viable component of the site will not be impacted.	• The ECoW will undertake or oversee a watching brief of works adjacent to the Firth of Forth SPA/Ramsar site (HRA7). • Plant and personnel will be constrained to a prescribed working corridor (HRA9). • Where safe to do so, visual and noise screening will be installed prior to construction along the works areas adjacent to the estuary in front of the breakwater and sheltered bay to screen the movement of vehicles, plant and site personnel from birds (HRA10). • The contractor will employ a 'soft-start' to noisy activities, as advised by the ECoW (HRA11). In addition to the avoidance and mitigation measures detailed above, the appointed ECoW will ensure these mitigation measures are implemented to avoid and reduce impacts on qualifying species. Monitoring surveys will also be undertaken by the employer's ecologist throughout construction to demonstrate the effectiveness of the mitigation.	
	<u>Disturbance/Displacement (foraging birds)</u> Disturbance could result in disrupted foraging behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Redshank was only recorded foraging at low tide on 8 occasions within the ZoI during the surveys. The infrequent observations of redshank at low tide suggests that habitat within the ZoI is not important for foraging redshank. In addition, the findings by Davies (2001) demonstrated that the benthic community of the upper shore around Grangemouth and Kinneil was less diverse and in lower abundances than the lower shore. During bird monitoring for GI works, redshank were the only species to react to GI related anthropogenic Potential Disturbance Events (PDE) on multiple occasions; dunlin and shelduck were the only other species to react on one occasion each. Redshank generally reacted to the disturbance from GI works by moving further away, up to a maximum of 30m, from their original location. Given the considerable area of alternative foraging habitat in close proximity to the site, notably mudflats at Kinneil Kerse and Skinflats, no impacts on foraging redshank are predicted. The following conservation objectives will be maintained: ensure distribution of the species within the site and no significant disturbance of the species are predicted.	No mitigation is required. However, mitigation measures that are proposed to prevent high tide roost disturbance impacts to redshank would remove impacts that could compromise the conservation objectives for foraging redshank.	No potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
	Impacts from lighting are not predicted given the existing lighting around the port/petrochemical plant area. Dwyer (2010) noted that redshank appeared to use lighting around the Port of Grangemouth to extend feeding time therefore potentially having a positive impact to foraging redshank.		
Ringed plover	<u>Habitat Loss</u> Construction of the Scheme will result in temporary habitat loss of up to 0.43ha within the SPA, (of which 0.25ha is mudflat habitat) and the permanent alteration of up to 1.15ha (of which 0.59ha is mudflat habitat). Ringed plover was recorded only once foraging within the permanently altered habitats in 2023. The survey data indicates, a single record of six birds foraging, that the area within the work footprint is not an important regular roost site for ringed plover and it is considered that the area of habitat lost would be negligible given the amount of remaining alternative roosting locations. The habitats lost either temporarily or permanently as a result of the Scheme are not considered to be functionally important for ringed plover and no impacts are predicted in relation to habitat loss. The following conservation objectives will be maintained: to avoid the deterioration of habitats, ensure distribution of species within the site and ensure distribution and extent of habitats supporting the species.	No mitigation is required. However, to ensure that the conservation objectives for ringed plover are not compromised, the following measures will be undertaken. The measures will prevent a change in the distribution of ringed plover and will protect the structure and function of the habitats that support the species within the sites: • A LEHMP will be developed which will include measures to reduce damage and restore the intertidal areas temporarily lost. • Plant and personnel will be constrained to a prescribed working corridor. • On completion of works all access tracks and working platforms will be removed in their entirety from the SPA. In addition to the avoidance and mitigation measures detailed above, an ECoW will be appointed who will ensure these mitigation measures are implemented to avoid and reduce impacts on qualifying species.	No potential for AESI
	<u>Disturbance/Displacement (high tide roosts)</u> Disturbance could result in disrupted roosting behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Ringed plover was recorded roosting within the ZoI at high tide predominantly in Sectors 9 and 10. A peak count of 210 birds (64% of the cited SPA population) was recorded roosting, foraging and loafing north of the petrochemical plant (sheltered bay) in September 2016. Ringed plover is an extremely tolerant species that habituates to anthropogenic activities rapidly. They are also tolerant of people, allowing people to approach as close as 30-50m before flushing when confronted with a lone walker on the mudflat (Cutts et al., 2013). At distances of over 100m from activity birds rarely showed any sign of disturbance and appeared often unperturbed when other species in their vicinity were reacting. Ringed plover roosts within 300m of works may be subject to disturbance and displacement throughout the construction period but only at high tide (i.e. for short periods). Disturbance is predicted to be localised, with birds potentially displaced to Bothkennar Pools and surrounding farmland and/or Kinneil Lagoons.	Given the complexities and scale of the Scheme, the construction of the flood defences along the site cannot be exclusively undertaken outside of the wintering bird season (October – March inclusive). The following measures will be undertaken during construction in order to prevent disturbance impacts on important overwintering bird populations: • Any temporary lighting will be designed to ensure minimal light spill (HRA4). • Any works undertaken adjacent to the SPA within Flood Cells 3 and 6 will be undertaken independently of each other, with at least one winter in between (HRA5). • The ECoW will undertake or oversee a watching brief of works adjacent to the Firth of Forth SPA/Ramsar site (HRA7).	Potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
	Displacement outwith the SPA is not predicted given the availability of alternative roost sites and therefore the population of the species as a viable component of the site will not be impacted.	• Plant and personnel will be constrained to a prescribed working corridor (HRA9). • Where safe to do so, visual and noise screening will be installed prior to construction along the works areas adjacent to the estuary in front of the breakwater and sheltered bay to screen the movement of vehicles, plant and site personnel from birds (HRA10). • The contractor will employ a 'soft-start' to noisy activities, as advised by the ECoW (HRA11). In addition to the avoidance and mitigation measures detailed above, the appointed ECoW will ensure these mitigation measures are implemented to avoid and reduce impacts on qualifying species. Monitoring surveys will also be undertaken by the employer's ecologist throughout construction to demonstrate the effectiveness of the mitigation.	
	<u>Disturbance/Displacement (foraging birds)</u> Disturbance could result in disrupted foraging behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Ringed plover was recorded foraging on seven occasions within the ZoI, with a peak count of 33 birds (10% of the cited SPA population) recorded at the mouth of the River Avon. Given the infrequent occurrences of birds recorded foraging within the ZoI, and the alternative foraging habitat located around Skinflats and Kinneil Lagoons, no impacts on foraging ringed plover are predicted. The following conservation objectives will be maintained: ensure population of the species as a viable component of the site, ensure the distribution of the species within the site, and no significant disturbance of the species.	No mitigation is required. However, mitigation measures that are proposed to prevent high tide roost disturbance impacts to ringed plover would remove impacts that could compromise the conservation objectives for foraging ringed plover.	No potential for AESI
Sandwich tern	<u>Habitat Loss, Disturbance/Displacement (high tide roosts and foraging birds)</u> Sandwich tern was not recorded under the permanent or temporary habitat loss footprint of the Scheme. The Firth of Forth is recognised as an important area for large numbers of Sandwich tern that congregate in the Forth post-breeding. Three small flocks (approximately 1% of the cited SPA population) were recorded roosting within the study area in August 2015 (4 birds) and September 2016 (two separate flocks of four and five birds). Five terns roosted on mud at low tide approximately 300m from the foreshore at the petrochemical plant and four birds roosted 80m north of the port entrance. All birds moved on as the tide approached. All other records were of birds in flight and foraging. There was a single peak count of four birds in September 2016 in sector 7 within the ZoI. As only infrequent, low numbers	No mitigation is required: Sandwich tern was not recorded utilising habitat that will be temporarily unavailable or permanently altered as a result of the Scheme and birds were recorded infrequently within the ZoI.	No potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
	of terns were recorded at a distance from the works area, it is considered that the immediate area surrounding the Scheme is not functionally important for terns. Therefore, no impacts on Sandwich tern are predicted in terms of the conservation objectives for the species.		
Scaup (650m visual ZoI)	<u>Habitat Loss, Disturbance/Displacement (high tide roosts and foraging birds)</u> Scaup have not been recorded in areas due to be permanently altered or areas unavailable during construction. A peak count of 28 scaup (6.4% of the cited SPA population) was recorded foraging in Sector 10 during rising and high tide. Substantial declines in scaup occurring on the Firth of Forth has been directly linked to sewage treatment improvement works - reduced sewage outputs leading to reduced mollusc abundance which supported less scaup (Campbell, 1984). Scaup is now only recorded in very low numbers in winter (Cook et al., 2013). Scaup was recorded within the 650m ZoI in relatively small numbers, feeding and loafing in open water and therefore less prone to disturbance from onshore activities. As these birds have been recorded on open water, rather than close to the shoreline, it is unlikely that the distribution or population size of scaup within the site will be significantly affected by the works, and therefore no impacts on scaup are predicted in terms of the conservation objectives for the species.	No mitigation is required. Scaup was not recorded utilising habitat that will be temporarily unavailable or permanently altered as a result of the Scheme and scaup are more likely to be found on open water.	No potential for AESI
Shelduck (650m visual ZoI)	<u>Habitat Loss</u> One record of 168 shelduck was noted under the habitat unavailable during construction and permanently altered habitat during the 2016 surveys, with a further three records (two, four and six birds) noted under these areas during 2023 surveys. The infrequent records within the works footprint suggests that there are other areas within the SPA/Ramsar site favoured by shelduck during the winter, and that the area lost as a result of the Scheme is not functionally important supporting habitat for this species. No impacts on are predicted in relation to habitat loss. The following conservation objectives will be maintained: to avoid the deterioration of habitats, ensure distribution of species within the site, and ensure distribution and extent of habitats supporting the species.	No mitigation measures are required. However, to ensure that the conservation objectives for shelduck are not compromised, the following measures will be undertaken. The measures will prevent a change in the distribution of shelduck and will protect the structure and function of the habitats that support the species within the sites: • A LEHMP will be developed which will include measures to reduce damage and restore the intertidal areas temporarily lost. • Plant and personnel will be constrained to a prescribed working corridor. • On completion of works all access tracks and working platforms will be removed in their entirety from the SPA. In addition to the avoidance and mitigation measures detailed above, an ECoW will be appointed who will ensure these mitigation measures are implemented to avoid and reduce impacts on qualifying species.	No potential for AESI
	<u>Disturbance/Displacement (high tide roosts)</u> Disturbance could result in disrupted roosting behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival.	No mitigation is required. However, mitigation measures that are proposed to prevent high tide roost disturbance impacts to other	No potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
	Shelduck was recorded roosting at high tide predominantly in Sectors 6 – 10 throughout the survey period. A peak count of 1,440 birds (32% of the cited population) was recorded at rising tide roosting in Sector 5 in September 2016. This is likely to include a large proportion of the annual moulting flock present within the Forth Estuary each year from July until September. Shelduck are extremely sensitive to moderate and high-level visual disturbance. Within the inner Forth estuary, Kinneil Kerse supports a large flock of moulting shelduck, a rare feature in Britain (Bryant, 1987; SNH, 2000; JNCC, 2001) and a peak count of 4,700 bird was recorded in August 2016 at low tide within the study area. A key pressure for the species is disturbance to potentially flightless moulting birds in the vicinity up to early October. Roosting birds within 300m of works may be subject to disturbance and displacement during the construction period and also potentially during maintenance works. Shelduck roost on open water as well as on land and, if disturbed, are likely to displace to an alternative area of open water a short distance further away from the disturbance source. The extent of nearby available open water is very large, therefore no adverse effects on site integrity are anticipated via impacts to roosting shelduck.	qualifying species would remove impacts that could compromise the conservation objectives for roosting shelduck.	
	<u>Disturbance/Displacement (foraging birds)</u> Disturbance could result in disrupted foraging behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Shelduck was frequently recorded foraging intertidally around the Port of Grangemouth, north of the petrochemical plant (sheltered bay) and east of Bothkennar Pools. A count of 446 foraging birds was recorded on a lowering tide in September 2015 in Sector 7, with birds foraging throughout all months of the surveys undertaken. A peak count of 4,700 birds (104% of the cited population) was recorded at low tide roosting, loafing and foraging at Sector 10 in August 2016. This is likely to include a large proportion of the annual moulting flock present within the Forth Estuary each year from July until September. Cutts and Allen (1999), in relation to flood defence works at Saltend on the Humber Estuary, observed that shelduck are susceptible to disturbance associated with construction activities, with a shift in location from preferred feeding areas within 250m of the works site in upper estuary areas. The diet of shelduck consists predominantly of salt-water molluscs primarily mud snail (*Hydrobia ulvae*) which is present in almost all estuaries, and often in large numbers. Spatial distribution is strongly influenced by the behaviour of this prey, particularly in relation to water depth. Shelducks are considered to have a high site fidelity and are totally reliant on wetland habitats due to unsuitable surrounding habitats and/or species limited habitat requirements.	No mitigation is required. However, mitigation measures that are proposed to prevent high tide roost disturbance impacts to ringed plover would remove impacts that could compromise the conservation objectives for foraging shelduck.	No potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
	Given the considerable area of alternative foraging habitat in close proximity to the site, notably mudflats at Kinneil Kerse and Skinflats, no impacts on foraging shelduck are predicted. The following conservation objectives will be maintained: ensure population of the species as a viable component of the site, ensure the distribution of the species within the site and no significant disturbance of the species		
Turnstone	Habitat Loss, Disturbance/Displacement (high tide roosts and foraging birds) Turnstone was not recorded in areas for permanently altered habitat or habitat unavailable during the construction period during any of the surveys for the Scheme. Turnstone is uncommon in the inner Forth (Symonds et al., 1984) and recent surveys reflect this with a peak count of four birds (0.5% of the cited SPA population) recorded along the breakwater in November 2016 and October 2022. Turnstone rely on rocky/stony shores (SNH, 2016b) and therefore tend to occur more in the outer than inner Forth. Given the low occurrence of birds around the Scheme it is likely that birds displaced during construction and potentially during maintenance works will be able to relocate within the local area, as was indicated by studies of the effects of the construction of Clackmannanshire Bridge on shorebirds (Dwyer, 2010). It is concluded that there will be no impacts on turnstone in terms of the conservation objectives for the species.	No mitigation is required. Turnstone was not recorded utilising habitat that will be temporarily unavailable or permanently altered as a result of the Scheme and was recorded infrequently in low numbers within the ZoI.	No potential for AESI
Wigeon (650m visual ZoI)	Habitat Loss Construction of the Scheme will result in temporary habitat loss of up to 0.43ha within the SPA (of which 0.25ha is mudflat habitat) and the permanent alteration of up to 1.15ha (of which 0.59ha is mudflat habitat). Wigeon was recorded only twice within the habitat temporarily or permanently unavailable – in January and March 2023, roosting in Sectors 10 and 9 respectively. The survey data indicates that the area within the work footprint is not an important regular roost site for wigeon and it is considered that the area of habitat lost would be negligible given the amount of remaining alternative roosting locations. The habitats lost either temporarily or permanently as a result of the Scheme are not considered to be functionally important for wigeon and no impacts are predicted in relation to habitat loss. The following conservation objectives will be maintained: to avoid the deterioration of habitats, ensure distribution of species within the site, and ensure distribution and extent of habitats supporting the species.	No mitigation is required. However, to ensure that the conservation objectives for wigeon are not compromised, the following measures will be undertaken. The measures will prevent a change in the distribution of wigeon and will protect the structure and function of the habitats that support the species within the sites: • A LEHMP will be developed which will include measures to reduce damage and restore the intertidal areas temporarily lost. • Plant and personnel will be constrained to a prescribed working corridor. • On completion of works all access tracks and working platforms will be removed in their entirety from the SPA. In addition to the avoidance and mitigation measures detailed above, an ECoW will be appointed who will ensure these mitigation measures are implemented to avoid and reduce impacts on qualifying species.	No potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
	<u>Disturbance/Displacement (high tide roosts)</u> Disturbance could result in disrupted roosting behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Wigeon was recorded roosting during rising and high tides throughout the ZoI with hotspots east of the Port of Grangemouth, north of the petrochemical plant (sheltered bay) and at the mouth of the River Avon. Given the moderate aggregations that roost at several hotspots within the ZoI (1 – 660 birds), displacement due to noise and visual stimuli during construction is possible at high tide, impacting on the distribution of the species within the site. Wigeon roosts within 300m of works may be subject to disturbance and displacement during the construction period, and also potentially during maintenance works, but only at high tide (i.e. for short periods). Disturbance is predicted to be localised, with birds potentially displaced to Bothkennar Pools and surrounding farmland and/or Kinneil Lagoons. Displacement outwith the SPA is not predicted given the availability of alternative roost sites within 1km of the Scheme and therefore the population of the species as a viable component of the site will not be impacted.	Given the complexities and scale of the Scheme, the construction of the flood defences along the site cannot be exclusively undertaken outside of the wintering bird season (October – March inclusive). The following measures will be undertaken during construction in order to prevent disturbance impacts on important overwintering bird populations: • Any temporary lighting will be designed to ensure minimal light spill (HRA4). • Any works undertaken adjacent to the SPA within Flood Cells 3 and 6 will be undertaken independently of each other, with at least one winter in between (HRA5). • The ECoW will undertake or oversee a watching brief of works adjacent to the Firth of Forth SPA/Ramsar site (HRA7). • Plant and personnel will be constrained to a prescribed working corridor (HRA9). • Where safe to do so, visual and noise screening will be installed prior to construction along the works areas adjacent to the estuary in front of the breakwater and sheltered bay to screen the movement of vehicles, plant and site personnel from birds (HRA10). • The contractor will employ a 'soft-start' to noisy activities, as advised by the ECoW (HRA11). In addition to the avoidance and mitigation measures detailed above, the appointed ECoW will ensure these mitigation measures are implemented to avoid and reduce impacts on qualifying species. Monitoring surveys will also be undertaken by the employer's ecologist throughout construction to demonstrate the effectiveness of the mitigation.	Potential for AESI
	<u>Disturbance/Displacement (foraging birds)</u> Disturbance could result in disrupted foraging behaviour, which could lead to decreased body condition and a reduction in reproductive success and individual survival. Wigeon was recorded within the ZoI foraging frequently across the entire survey area. Wigeon feed predominantly on leaves, seeds, stems and root bulbs of pond weeds, fine grasses, horsetails and eelgrass, as well as algae (Owen and Thomas, 1979). Wigeon are gregarious, forming large flocks and can feed at night, especially in marine habitats. Wigeon flocks feed close to the water's edge.	No mitigation is required. However, mitigation measures that are proposed to prevent high tide roost disturbance impacts to wigeon would remove impacts that could compromise the conservation objectives for foraging wigeon.	No potential for AESI

Qualifying Interest	Assessment of Impacts	Avoidance and Mitigation	Potential for Adverse Effects on Site Integrity (AESI)
	Within estuaries wigeon will feed on seagrass (*Zostera* spp.). The nearest record of mixed *Zostera* spp. is at Carriden Bay approximately 5km from the Scheme (Zoutenbier et al., 2016). Wigeon are also known to graze on arable fields. Given the considerable area of alternative foraging habitat in close proximity to the site, notably mudflats at Kinneil Kerse and Skinflats, surrounding arable land and the known *Zostera* spp. site at Carriden Bay, no impacts are predicted on foraging wigeon, in relation to disturbance/displacement. The following conservation objectives will be maintained: to avoid the deterioration of habitats, ensure distribution of species within the site, and ensure distribution and extent of habitats supporting the species.		

4.11 AA Conclusion

No AESI has been identified due to loss of habitat as a result of the Scheme. Potential AESI have been identified as a result of disturbance to roosting birds for 11 qualifying interest species of the Firth of Forth SPA/Ramsar site during construction and maintenance works. Large numbers of birds aggregate at roost areas across the ZoI at certain times of year and states of tide.

After mitigation, potential impacts on cormorant, and therefore the Loch Leven SPA/Ramsar site, will not result in an AESI.

Timing works to fully avoid disturbance impacts during sensitive periods is not considered possible due to the large-scale nature of the Scheme. In addition, visual screens high enough to fully conceal all works from qualifying species are not practical. Screens 2m in height will be installed at relevant locations along the estuary frontage to minimise effects by reducing the visual/noise impacts, in conjunction with other mitigation measures. However, with the precautionary principle underpinning the HRA approach, the inability to time the construction programme to fully avoid sensitive periods and fully screen works from view, an AESI cannot be discounted.

If displacement is sufficiently severe in its intensity, frequency and/or duration it could potentially constitute an AESI, for example, if there were a reduction in numbers of birds in the Firth of Forth SPA/Ramsar site, displacement to less suitable or unsuitable areas of habitat within the SPA, and/or loss of body condition potentially affecting survival and future breeding success rates. Whilst high-severity disturbance events are considered likely to be rare, a degree of uncertainty exists around the residual disturbance after mitigation, and therefore a low likelihood of AESI still remains.

Due to there being a low risk of AESI, the provisions of Article 6(4) of the Habitats Directive 92/43/EEC need to be met. Further information is provided in Section 6: Stage 3 (Alternative Solutions) and Section 7: Stage 4 (Imperative Reasons of Overriding Public Interest) and an appropriate package of compensatory measures is described in Section 8 (Compensation).

5. Provisions of Article 6(4): Statement about Alternative Solutions, Imperative Reasons of Overriding Public Interest and Compensatory Measures

The question underpinning the HRA is: Can it be ascertained that the proposal will not adversely affect the integrity of the site beyond reasonable scientific doubt?

Whether the Scheme would not have an adverse effect on the integrity of the site has been determined by assessing whether, following the implementation of the mitigation measures identified in this document, it would affect the achievement of one or more conservation objectives set for the Firth of Forth SPA and Ramsar site. As stated in Section 4.11 (AA Conclusion), it is concluded that the Scheme could potentially compromise the conservation objectives due to disturbance of 11 qualifying interest species.

Based on available data and professional judgement, it is considered that the risk of an adverse effect on site integrity of the Firth of Forth SPA and Ramsar site is extremely small. However, as the precautionary principle underpins the HRA approach, it is concluded that the risk of AESI cannot be ruled out beyond reasonable scientific doubt. Due to the requirement to follow the precautionary principle, and the inherent uncertainties associated with ecological systems and assessments, it has been concluded that Scheme could have an adverse effect on site integrity in relation to disturbance of qualifying bird species during the construction and maintenance period.

As a potential AESI has been identified following application of the precautionary principle, there is a need to proceed to the later stages of Assessment of Implications on European Sites (AIES), namely considering alternative solutions, Imperative Reasons of Overriding Public Interest (IROPI) and compensatory measures.

The purpose of the Statement about Alternative Solutions, Imperative Reasons of Overriding Public Interest and Compensatory Measures (SASICOM) is to:

- assess whether there are feasible alternatives to the proposed Scheme design that would have no or less impact on the integrity of the SPA, taking into consideration buildability and cost effectiveness. In order for an alternative solution to be deemed feasible, it must meet the Scheme objectives (Section 6.2 Scheme Objectives);
- assess whether or not there are IROPI related to the Scheme; and
- identify the compensatory measures necessary to ensure that the coherence of the European site network is protected.

6. Stage 3 (Alternative Solutions)

6.1 Introduction

Stage 2 (Appropriate Assessment) concluded that it cannot be proven beyond reasonable scientific doubt that the Scheme construction and maintenance phases will avoid AESI with appropriate mitigation measures in place. Therefore, the provisions of Article 6(4) of the Habitats Directive 92/43/EEC need to be met. As the Scheme is of strategic national importance[3] and there are imperative reasons of overriding public interest (as set out in Section 7 Stage 4), the Competent Authority (Falkirk Council) may wish to consent even if an AESI cannot be ruled out. However, before the Competent Authority can confirm the Scheme as proposed, it must be demonstrated that there are no feasible alternative solutions that can deliver the objectives of the Scheme (Section 6.2) without causing an AESI.

This chapter provides an assessment of possible alternative solutions. It:

- identifies the key objectives and requirements of the flood protection project;
- identifies all feasible alternative means of meeting the objectives; and
- assesses each identified feasible alternative against the criteria used in the AA to assess effects on the conservation objectives of the European sites.

6.2 Scheme Objectives

The need for the Scheme, and its priority status, is set out in the Forth Estuary Flood Risk Management Strategy (FEFRMS) published by SEPA and approved by the Scottish Ministers on 14 December 2015 (SEPA, 2015) and the associated Local Flood Risk Management Plan published by the City of Edinburgh Council (the Lead Local Authority) on 22 June 2016 (The City of Edinburgh Council, 2016). The relevant objectives from the FEFRMS are noted in Table 6.1 below.

Table 6.1: Forth estuary local flood risk management strategy objectives

Objective ID	Objective Description
10035	Reduce economic damages to residential and non-residential properties in Carron and Carronshore caused by flooding from the River Carron and coastal flooding
10036	Reduce economic damages to residential and non-residential properties in Falkirk caused by flooding from the River Carron
10040	Reduce economic damages to residential and non-residential properties in Grangemouth caused by river flooding and coastal flooding
10041	Reduce risk to people in Bonnybridge, Denny, Carron and Grangemouth from river and coastal flooding

During the early development of the Scheme, a set of general objectives[4] were developed. These objectives were subsequently further refined into more focused and specific Scheme objectives. The Scheme objectives set out below provide the additional granularity and detail that is required to assess whether potential alternatives would meet the Scheme objectives. The Scheme objectives set out below include additional detail to the Scheme objectives that are included in the EIAR and option appraisal, relevant to the HRA process.

The Scheme objectives are as follows:

[3] National Planning Framework 4, Scottish Government (2023)
[4] https://www.grangemouthfloodscheme.com/objectives

GFPS-OBJ1. Provide a 1 in 200-year (0.5% annual exceedance probability) standard of protection from coastal and fluvial flooding for residential and non-residential properties in Grangemouth and the surrounding communities of Wholeflats, Glensburgh, Langlees, Carron, Carronshore and Camelon (Stirling Road) (together "the Communities").

GFPS-OBJ2. Provide flood protection to important transport infrastructure in the Communities, including the A9 (including Stirling Road), A905 (Wholeflats Road and Inchyra Road) and B902 (Carron Road).

GFPS-OBJ3. Provide flood protection to industry in the Communities, including the Port of Grangemouth, the petrochemical works and refinery (including the Kinneil Terminal).

GFPS-OBJ4. Reduce risk to life and limit disruption from flooding within the Communities.

GFPS-OBJ5. Reduce economic damages within the Communities arising from flooding.

GFPS-OBJ6. Maintain and enhance the existing Grangeburn Road Flood Protection Scheme on the Grange Burn and deliver a flood relief channel capable of conveying increased flows to the River Avon.

In meeting these objectives, the Scheme will contribute to achieving Objectives 10035, 10036, 10040 and 10041 (identified in Table 6.1) and the implementation of Actions 100400006 and 100400017 of the Forth Estuary Flood Risk Management Strategy (Table 7.1).

6.3 Assessment of Alternative Solutions

Table 6.2 below details the options that the project team considered during the option appraisal stage, which includes 'Do nothing', 'Do minimum' and 'Do something' options. At options appraisal, many other alternatives were assessed that partially met Scheme objectives and were located away from the SPA. However, such options on their own would not be feasible as rather than preclude the need for downstream defences, they would only reduce their relative heights. These options focussed on fluvial and pluvial flooding and would not change the height or extent of flood defences along the estuary frontage or around the Port as flood defences are required to stop coastal flooding. Therefore, they are not considered in Table 6.2. Similarly, whilst the focus in Table 6.2 is those defences that are adjacent to the SPA, the overall project contains significant additional lengths of flood defence. Whilst the 'Do nothing' and 'Do minimum' options would not impact upon the SPA, they do not meet the Scheme objectives. As such, these options do not represent viable alternatives to the preferred option and can be discounted.

All the 'Do something' options that were considered (apart from the preferred option), also failed to meet some or all of the Scheme objectives and therefore also do not represent viable alternatives and can be discounted.

Table 6.2 demonstrates that Option 4 'Do Something: Flood defences at the edge of the Firth of Forth SPA' (combined with additional defences that do not have LSE) is the only option that achieves all the Scheme objectives, indicating that there are no feasible alternatives for works at this location.

Table 6.2: Options considered during option appraisal

Option	Description	Achieves Scheme Objectives	Comments	Potential Effects on SPA/Ramsar
1	Do nothing option: construct no new flood defences and make no repairs of existing flood defences.	No	This option would not achieve Scheme Objectives GFPS-OBJ1, GFPS-OBJ2, GFPS-OBJ3, GFPS-OBJ4, GFPS-OBJ5 and GFPS-OBJ6. This option would not protect people, property or infrastructure or avoid economic damages and can therefore be discounted as it is not a viable alternative.	None, as no work proposed in or adjacent to SPA/ Ramsar.
2	Do minimum option: construct no new flood defences. Repair and maintain existing defences.	No	This option would not achieve Scheme Objectives GFPS-OBJ1, GFPS-OBJ2, GFPS-OBJ3, GFPS-OBJ4 and GFPS-OBJ5. This option would only provide limited protection to those properties and people protected by the existing defences on the Grange Burn and those that benefit from the flood relief channel. A significant number of people, properties and infrastructure would remain at risk of flooding with considerable economic damages and therefore this option can also be discounted as it is not a viable alternative.	None, as no work proposed in or adjacent to SPA/ Ramsar.
3	Do something option: Natural Flood Management	No	This option would not achieve Scheme Objectives GFPS-OBJ1, GFPS-OBJ2, GFPS-OBJ3, GFPS-OBJ4, GFPS-OBJ5 and GFPS-OBJ6. Natural flood management would only offer a very marginal reduction in fluvial flows, with significant numbers of people, property and infrastructure remaining at risk of flooding. Natural flood management in the coastal areas would not reduce the predicted extreme tide levels and therefore not reduce the risk of tidal flooding. This option can also be discounted as it is not a viable alternative.	Changes in land use across the whole Firth of Forth could change the behaviour of qualifying species within the SPA/Ramsar site.
4	Do something option: Flood defences at the edge of the Firth of Forth SPA (preferred option/ current proposal)	Yes	This option would achieve Scheme Objectives GFPS-OBJ1, GFPS-OBJ2, GFPS-OBJ3, GFPS-OBJ4, GFPS-OBJ5 and GFPS-OBJ6.	Permanent and temporary habitat loss. Disturbance to qualifying species during construction and maintenance (particularly roosting birds).
5	Do something option: Flood defences set back from Firth of Forth SPA within the Port of Grangemouth and petrochemical plant	No	This option would only partly achieve Scheme Objectives GFPS-OBJ1, GFPS-OBJ2, GFPS-OBJ3, GFPS-OBJ4 and GFPS-OBJ5. This option would not provide protection to industry within the Communities including the Port of Grangemouth and the petrochemical plant. Important infrastructure would also remain at risk. Significant economic damages would not be avoided and therefore this option can also be discounted as it is not a viable alternative.	Potential disturbance to qualifying species during construction and maintenance (likely only birds roosting at estuary edge).

Option	Description	Achieves Scheme Objectives	Comments	Potential Effects on SPA/Ramsar
6	Do something option: Tidal barrier/ barrage across the Firth of Forth.	No	This option would only partly achieve Scheme Objectives GFPS-OBJ1, GFPS-OBJ2, GFPS-OBJ3, GFPS-OBJ4 and GFPS-OBJ5. To accommodate the barrier and lock structure, this option would result in a band of temporary and permanent SPA habitat loss which would span the width of the Firth of Forth. Qualifying species could be disturbed during construction, operation and maintenance works. The option would require complex logistical, engineering and construction solutions. Additional flood defences would be required around parts of the perimeter of the petrochemical plant, adjacent to the River Avon and within 100m of the SPA to address the fluvial flood risk. These defences could disturb qualifying species. This option would not provide an affordable solution. The estimated cost is likely to be in the range of £5-10 billion, which is significantly greater than the total estimated economic benefits of the Scheme. The cost would also be unaffordable to both Falkirk Council and Scottish Government. This option would also fail to minimise negative environmental impacts and would result in significant impacts. Therefore, this option can be discounted as it is not a viable alternative.	Permanent and temporary habitat loss. Disturbance to qualifying species (waders and waterbirds) during construction, operation and maintenance works.

6.3.1 Alternative design options within the preferred option:

The preferred option, Option 4 'Do Something: Flood defences at the edge of the Firth of Forth SPA', requires new defences to be built along the SPA boundary. This may lead to AESI for the Firth of Forth SPA due to visual and noise disturbance and the option has undergone a number design iterations to mitigate this AESI as much as possible. Table 6.3 identifies the assessment of alternative delivery mechanisms and the final preferred option taken forward from this assessment. The key alternative delivery mechanisms focussed primarily on the localised alignment of the proposed flood defences (e.g. within or just outside the environmentally sensitive sites), and the different construction methodologies available.

Table 6.3: Alternatives considered to deliver the preferred 'Do Something' option (Option 4)

Ref	Description	Technically Feasible to Deliver	Issues/ benefits	Decision
Option: Construction of flood defences on alternative alignment				
A	Construct flood defences on top of river bank adjacent to site security fence outwith active petrochemical plant (current proposal)	Yes	• Avoids significant health and safety risks by separating flood defences from operational major accident hazard site. Flooding has the capacity to act as an initiating event to a COMAH Major Accident Hazard at a number of the industrial installations at Grangemouth. The scheme will significantly reduce this risk. **(benefit)** • All infrastructure (within the port and petrochemical plant) is protected from extreme sea levels and wave action. **(benefit)** • Opportunities for some bird roosting habitat to be created on top of coastal revetment. **(benefit)** • The petrochemical plant and the port can remain operational during construction phase. **(benefit)** • The permanent and temporary habitat loss at the margins of the SPA has been minimised throughout the design process. **(benefit)** • Potential adverse effect on site integrity of the SPA as disturbance to qualifying species roosting at high tide could not be fully mitigated during construction and maintenance. Therefore, compensation would be required. **(issue)** • Some coastal defences would require access tracks and works within an area of extremely soft sediment, which would require a bespoke engineering solution and an extended construction programme due to significantly reduced working time around tides. **(issue)**	Preferred location for proposed flood defences – temporary and permanent habitat loss is at the margins of the SPA, with potential for additional roosting habitat to be created. Significantly reduces the health and safety risks associated with flooding being an initiating event to a COMAH Major Accident Hazard. Allows the port and petrochemical plant to remain operational during construction phase and they are protected from flooding.
B	Construct flood defences on top of bank landward of site security fence i.e. within petrochemical plant	No	• Avoids temporary and permanent loss of habitat within the SPA. **(benefit)** • Avoids the requirement for access tracks and works within an area of extremely soft sediment to build some coastal defences, which would require a bespoke engineering solution and increase construction time due to significantly reduced working time around tides. **(benefit)** • Creates a significant health and safety risk by including flood defences within operational major accident hazard site. **(issue)** • Critical elements of the petrochemical plant (pipelines and railway line etc.) would remain at risk of flooding, thereby failing to meet a key scheme objective. In addition, flooding would remain as a potential initiating event for a COMAH Major Accident Hazard. **(issue)** • Access to the Forth and Tay Navigation Centre (within the port) would be prevented during a flood event, resulting in significant economic losses, thereby failing to meet a key scheme objective as well as potentially leading to safety concerns relating to vessel collisions and groundings. **(issue)** • Not protecting certain parts of the industrial complex could result in a major pollution incident if pipelines and other infrastructure were not protected and exposed to extreme sea levels and waves and the potential damage to this infrastructure. **(issue)**	Not taken forward due to significant safety risks and technically not feasible due to the number of pipelines and apparatus within the port and petrochemical plant.

Ref	Description	Technically Feasible to Deliver	Issues/ benefits	Decision
C	Construct flood defences further into the SPA e.g. at toe of bank rather than top of bank.	Yes	• Avoids significant health and safety risks by separating flood defences from operational major accident hazard site. **(benefit)** • All infrastructure (within the port and petrochemical plant) is protected from extreme sea levels and wave action. **(benefit)** • Flood defence structure would require a much larger construction footprint as it would effectively form a quay wall on the edge of the SPA, requiring longer piles and need larger construction plant to install the piles. (**issue**) • The duration of construction works would need to be extended to compensate for the poorer ground conditions likely to be encountered and the significantly reduced working time around tides. **(issue)** • Flood defences would encroach further into the SPA (than other options), which would result in greater temporary and permanent habitat loss within the SPA. **(issue)** • Potential adverse effect on site integrity of the SPA as disturbance to qualifying species roosting at high tide could not be fully mitigated during construction and maintenance. Therefore, compensation would be required. **(issue)** • A larger permanent works footprint would be required, which would take up more land within the SPA. **(issue)**	Not taken forward due to greater technical issues. This option is also likely to result in more temporary and permanent habitat loss within the SPA and result in more disturbance to qualifying species than Option A.
Option: Alternative methods of constructing flood defences				
D	Wall type: steel sheet piles with no concrete cladding Piling method: conventional vibrodriving piling rig with pre-auger Temporary works access: working from existing access roads or temporary stone haul roads installed on the landward side of the proposed flood defences	Yes	• Steel sheet piles can be installed using a wide range of construction plant to cater for the different physical conditions that could be encountered. **(benefit)** • This method allows for multiple items of construction plant to operate, which would help reduce the disturbance impact on the SPA. Defences could be constructed at a quicker rate and over a larger area, reducing the potential noise in a single location. **(benefit)** • If required (depending on ground/ physical conditions) the area where the piles will be installed can be pre-augured to reduce the risk of piles encountering an obstruction and minimise delays to construction. **(benefit)**	Preferred method for majority of flood defences, due to the speed of construction and potential for multiple areas to be worked on simultaneously. The construction method means a wide range of construction plant can be utilised, rather than specialist equipment. Option F is also defined as a preferred method for constructing flood defences.

Ref	Description	Technically Feasible to Deliver	Issues/ benefits	Decision
E	Wall type: sheet piles with no concrete cladding Piling method: pile pressing rig with crane to lift piles into rig Temporary works access: working from existing access roads or temporary stone haul roads	No	• The advantage of the pressing rig is its lower noise and vibration when compared to a conventional rig. The rig sits directly on top of the piles and moves along the top of the piles. **(benefit)** • This method of installing piles is slower than conventional methods, resulting in a longer construction period. **(issue)** • As the port and petrochemical plant are constructed on reclaimed ground, the likelihood of encountering obstructions is high. This method of installation is prone to delays due to encountering obstructions. **(issue)**	Not taken forward due to extended construction durations and significant risk of encountering obstructions in the ground preventing piles from being installed to required depths.
F	Wall type: bored piles with reinforced concrete wall stem. Piling method: Conventional continuous flight auger piling rig Temporary works access: working from existing access roads or temporary stone haul roads	Yes	• This method is necessary to address technical design concerns relating to the installation of driven sheet piles into the ground where soil improvement is proposed. **(benefit)** • This method of construction is slower than driving steel sheet piles. **(issue)** • Bored pile installation uses similar construction equipment to that used to install sheet piles and therefore there is no real difference in access requirements and/ or noise and disturbance. **(benefit)**	Preferred method along estuary shoreline between Grange Burn and River Avon.

6.4 Stage 3 (Alternative Solutions) Conclusion

The preferred option is Option 4 'Do Something: Flood defences at the edge of the Firth of Forth SPA', with the defences located at the top of the river bank/ coastal edge (sub-option A) which are formed using sheet piles (sub-option D) for the majority of defences: a concrete bored pile (sub-option F) is adopted along the estuary between Grange Burn and River Avon where sheet piles are technically unsuitable. Option 4 has been selected as it is likely to have the least AESI on the SPA and reduces the land take within the SPA. It can also be constructed in a timely manner and is a more technically feasible and viable option compared to the other options outlined in this chapter.

There are no feasible alternatives that would achieve a 1 in 200-year standard of flood protection for the area protected by the Scheme, which are less likely to cause AESI to the Firth of Forth SPA, achieve the Scheme objectives, and meet the provisions of Article 6(4) of the Habitats Directive 92/43/EEC. Therefore, the next stage of the HRA process (Stage 4) is to determine whether the Scheme as proposed has Imperative Reasons of Overriding Public Interest (IROPI).

7. Stage 4 (Imperative Reasons of Overriding Public Interest)

7.1 Introduction

As it has been demonstrated that there are no alternative solutions to the Scheme, the provisions of Article 6(4) of the Habitats Directive 92/43/EEC require that it is demonstrated that the Scheme must be carried out for imperative reasons of overriding public interest, in order that consent can be granted.

This section provides information to demonstrate that there are imperative reasons of overriding public interest (IROPI) that justify the consent of the Scheme, despite its potential impact on the SPA/ Ramsar site.

7.2 Policy and Legislation

As stated in Section 1.1 (Project Background), the need for a flood protection scheme for the Grangemouth area was identified through the Flood Risk Management planning process as set out in the Flood Risk Management Act (Scotland) 2009. The Forth Estuary Flood Risk Management Strategy published by SEPA in 2015 sets out a series of high-level Objectives and Actions relating to flood risk management in the Forth Estuary with Objectives 10035, 10036, 10040, 10041 (refer to Table 6.2) and the implementation of Actions 100400006 and 100400017 (refer to Table 7.1) being particularly relevant to the Scheme. Action 100400006 specifically identifies the Scheme and gives it a National Ranking of 1 out of 42 flood protection schemes. This ranking was given due to a combination of the number of properties at risk of flooding (approximately 1,400 at the time) and the potential economic damages (£6.0 billion) avoided following implementation of the Scheme.

Table 7.1: Forth estuary local flood risk management strategy actions

Action ID	Action Description
Flood Protection Scheme/ Works (100400006)	A flood protection scheme has been proposed for the Grangemouth area. It would include the River Carron, Grange Burn, River Avon and the Forth Estuary shoreline. The scheme would consist of flood defences, sediment management, tidal barriers/ gates and natural flood management and would provide a 1 in 200-year standard of protection. Implementation of this scheme is likely to span a 10-year period from 2017-2027.
Maintain Flood Protection Scheme (100400017)	Continue to maintain the existing Grangeburn Road Flood Protection Scheme on the Grange Burn. The scheme includes a flood relief channel conveying flows to the River Avon.

The NPF4 (Scottish Government, 2023), adopted in February 2023, is the long-term (to 2045) national spatial strategy for Scotland and replaces NPF3 (Scottish Government, 2014) and Scottish Planning Policy (Scottish Government, 2014). In conjunction with the Local Development Plan, NPF4 forms the statutory development plan for any given area of Scotland. Both plans are read together, however where there is any difference in policy content the more recent publication takes precedence. With regards to the Scheme, the Falkirk Local Development Plan 2 (FLDP2) (Falkirk Council, 2020) which was adopted by Falkirk Council in 2020, and NPF4 form the statutory development plan for the Falkirk area. A flood protection scheme for Grangemouth is identified as a National Development of strategic national importance in NPF4 and supported within the FLDP2, which states that it '*will address flood risk From the Forth Estuary the Rivers Carron and Avon, and the Grange Burn*'. The FLDP2 also notes that '*the LDP will need to ensure that no development takes place which would impede or unduly constrain options for the necessary works*' of the Scheme.

The Future Grangemouth Vision 2025 notes the construction of the Scheme as a key action (Scottish Enterprise and Chemical Sciences Scotland, 2017). Falkirk's Tax Incremental Finance Initiative, approved by the Scottish Ministers, supports the Grangemouth Investment Zone and included a specific action relating to the Scheme works.

The need for the Scheme is identified in national, regional, and local policies, strategies and plans. Additional information on these, including the Local Flood Risk Management Plan for the Forth Estuary Local Plan District

(Falkirk Council, 2023) and the Forth Estuary Flood Risk Management Strategy (SEPA, 2015), is provided in Section 1.1 (Project Background).

The Scheme will ensure that 2,760 residential properties, more than 6,000 people, 1,200 non-residential properties, 23km of roads and nationally important infrastructure (namely the Port of Grangemouth and petrochemical plant), are protected from current and future flood risk. The long-term protection of these national assets and the surrounding area is of imperative overriding public interest.

7.3 Imperative Need

As has been identified, the town of Grangemouth and surrounding communities are at risk of flooding with significant numbers of people and properties at risk. Existing flood defences provide limited benefit with properties starting to be affected by flooding from around the 1 in 5-year event (20% annual chance of occurring) to 1 in 10-year event (10% annual chance of occurring). Projected sea level rises due to climate change and increases in rainfall intensity will significantly increase the risk to people and property. Therefore, without the Scheme there would be an unacceptably high level of flood risk.

The Scheme is imperative to significantly reduce risk to life and property. In the interests of human health and public safety the Scheme will provide flood protection to an area which is currently at risk of flooding. The Scheme will also provide significant economic benefits to both the local and national economy due to the significant flood damage costs that would be avoided.

7.4 Public Interest

Regular and/or severe flooding may cause notable adverse effects on local communities by causing damage to residential, commercial and civic property, public spaces and infrastructure as well as human health. Living within a flood risk area can increase one's risk of mortality, injury, illness or stress and have an effect on social wellbeing (Penning-Rowsell et al. 2013; Scottish Executive, 2007). Regular flooding can also affect livelihoods due to increased maintenance costs, insurance premiums and disruption of commercial activity, and it can have a detrimental effect on residential and commercial property values and discourage investment in flood affected areas, leading to gradual economic decline (JBA, 2005).

The Scheme will provide long term flood protection to both public and privately-owned land in the Grangemouth area. The 2,760 residential and 1,200 non-residential properties at flood risk in the Grangemouth and surrounding area that the Scheme will protect is significant. In addition, the petrochemical plant and port are classified as nationally important infrastructure, whereby a temporary or permanent closure would have significant impacts on the Scottish and UK economies as well as environmental and social impacts and long-term reputational/commercial damage. The Scheme will provide long-term benefits to the local communities that are directly protected and also provide commercial confidence to the wider area and Scotland.

The Scheme will provide flood protection to an area which is currently at risk of flooding and will benefit the following:

- more than 6,000 people;
- 2,760 residential properties;
- 1,200 non-residential properties (including those within the port/industrial hub and within Grangemouth and surrounding communities);
- community buildings:
    - one care home;
    - one community centre;
    - four medical facilities;
    - three school facilities;
    - one sports complex;

- one library; and
- four places of worship.

- utility sites:
  - one waste water treatment plant; and
  - infrastructure for the following utilities and services: gas, electricity, telecommunications, water and sewage.

- transport:
  - 23km of roads;
  - one bus depot;
  - core paths; and
  - one private railway line.

- designated cultural heritage sites:
  - nine listed buildings; and
  - one UNESCO World Heritage Site (Antonine Wall).

7.4.1 Residential Properties/ Community Facilities

The Scheme will protect 2,760 residential properties and 11 community facilities. They will be protected from potential flooding impacts, ranging from lack of access and inconvenience where flood water surrounds their property, to the complete loss of possessions in the properties and significant damage to their homes. The latter could result in the need for residents to vacate their homes for 6-9 months or more whilst their homes are decontaminated, dried and restored to a habitable condition. The financial cost of such flooding is considerable and the impacts on health, particularly mental health, may be long term as those affected may live in fear of a repeat flood event.

7.4.2 Transport Infrastructure

The Scheme will protect around 23km of roads in Grangemouth and surrounding areas, enabling roads and footpaths to remain open during and after a flood event. This will provide considerable benefit through the reduction in delays caused from roads being partially closed or impassable. The A9, A904, A905 and Forth Clyde Way could all be affected by flooding without the Scheme. These roads provide crucial access/ egress from the petrochemical plant and port in the event of an emergency, with the A9 also providing a key route to Forth Valley Royal Hospital. The closure of these roads during a flood could increase the risk to life of people.

Without the Scheme the main access into the Port from Powdrake Road would need to be closed during a 1 in 200-year flood event, which would prevent all access and egress from the Port and result in economic damage and disruption within supply chains.

7.4.3 The Port of Grangemouth and Petrochemical Plant

The Port of Grangemouth and petrochemical plant are of national importance and need to be protected from flooding. Due to the size and complexity of the industrial area, it is difficult to quantify the exact monetary benefits of the Scheme. The economic assessment carried out for the Scheme quantified the benefits of protecting the port and petrochemical works to be in excess of £1.71 billion.

The INEOS petrochemical operated sites:

- employ over 1,650 people directly and a significantly larger number indirectly through the supply chain network, both locally to the central belt of Scotland further afield;
- produce over 1.3 million tonnes of chemical products annually at the site, including a range of fuels;

- have benefited from over £450 million of investment in the site recently and up to a further £1 billion planned in the coming years; and
- generated approximately 4% of Scotland's GDP (2016 figures) and is the first UK site to import US shale gas – ethane.

Any changes to the operational output from the petrochemical plant due to flooding would have severe short and medium-term impacts for the UK and the Scotland. The site is currently responsible for processing up to 40% of the oil and gas that is extracted from the UK's North Sea oil and gas fields and directly receives the Forties Pipeline (the main export pipeline from the UK's North Sea oil and gas fields). The flow of oil and gas from the Forties Pipeline is significant and any interruption in flow would have implications for the oil and gas production in the North Sea and the UK's fuel security. Whilst operational changes will occur at the current Petroineos site within the next few years, the site is expected to remain an industry hub as a fuel import/export facility.

Multiple pipelines are located throughout the site and link directly to the port, where further chemical separation/ processing takes place. These pipes deliver surplus products (gases) from the refining process and are used by multiple operators at the Grangemouth petrochemical plant to produce products which are significant contributors to Scotland's GDP. Given the location of pipelines and storage tanks, it is possible that during a flood event this infrastructure could be damaged and lead to the release of chemicals and other products that could result in pollution and contamination.

The Forth and Tay Navigation Centre is located near the main entrance lock gates within the port. The navigation centre controls all commercial shipping in the Firth of Forth and Tay Estuary. Flooding of this facility would make it inoperable and shipping in the Firth of Forth and Tay Estuary would be impacted, by restricting vessel movements in and out of all their commercial ports.

A large number of commercial tenants are located within the Port of Grangemouth and would be impacted by a flood event. An estimated 9 million tonnes of cargo pass through the port each year, which represents as much as 30% of Scotland's GDP (Forth Ports Group, 2023). There would be significant economic losses associated with the re-routing of goods to other ports in the UK and the subsequent distribution by road and rail together with indirect costs associated with the significant delays in distribution that would occur.

7.4.4 Other Non-residential Properties

A significant number of small and large commercial businesses throughout the Scheme extent would be impacted by a 1 in 200-year flood event and also the more frequent events that the Scheme will protect against. These include small local shops, garages, restaurants and hotels through to nationwide businesses providing plant and equipment hire and manufacturing. These businesses sustain hundreds of local jobs and are a key contributor to the local economy.

7.4.5 Economic Benefits

Economic assessments conducted for the Scheme have calculated that implementation of the proposed flood defences would result in a benefit of at least £2.4 billion to the national economy. The assessments considered:

- Direct and indirect flood risk damages, including damages to vehicles; and
- Potential downtime in economic activity due to flood events in the absence of flood defence measures;
- Improved development opportunities in areas that would be prone to flooding in the absence of the Scheme;
- Health, mental health and risk to life;
- Evacuation and emergency services; and
- Net carbon benefits associated with flood damages being avoided.

7.4.6 Other Benefits

Additionally, the Scheme would have the following benefits which were not considered within the economic assessments:

- Creation of jobs (and training opportunities) associated with the construction of the Scheme;
- Reduced requirement for pollution and debris clean-up following a flood event;
- Reduced closure of roads and traffic diversions;
- Reduction in loss of education from affected school facilities and general flood related disruption; and
- Jobs protected as businesses continue to operate within the Scheme area.

7.5 Imperative Reasons of Overriding Public Interest

The Scheme must be carried out for imperative reasons of over-riding public interest. If no flood defences were provided to Grangemouth and the surrounding communities, this would have the inevitable (over time) consequence of increased and repeated flooding that would have fundamental, and potentially catastrophic, consequences for the communities and the economy at both a local and national level.

As described, the Scheme will deliver very substantial and long-term public benefits in protecting the following from flooding: communities, residential and commercial properties, and infrastructure (including the nationally important Port of Grangemouth).

As explained elsewhere within this HRA (Section 4), the risk of harm to the SPA is low and the approach taken is precautionary as it cannot be demonstrated beyond reasonable scientific doubt that there will not be an AESI arising from localised disturbance to roosting birds.

Consequently, measures have been proposed to avoid, reduce, mitigate and compensate for the potential impacts, in line with the mitigation hierarchy and HRA process. A suitable package of compensatory measures has been proposed at Kinneil and Bothkennar proportionate to the potential effects of the Scheme, and to ensure the overall coherence of the European Sites Network.

The public interest in the Scheme overrides the limited harm, or risk of harm, to the Firth of Forth SPA and Ramsar site. It has been demonstrated that the Scheme is required for imperative reasons of overriding public interest and the provisions of Article 6(4) of the Habitats Directive 92/43/EEC have been met.

8. Compensation

8.1 Introduction

With the precautionary principle underpinning the HRA's conclusions that there could be adverse effects on site integrity, and following confirmation of no alternative solutions and that the Scheme is required for imperative reasons of overriding public interest, compensatory measures must be taken to ensure that the overall coherence of the European site network is protected. Compensatory measures '*…aim to offset the negative impact of a project and to provide compensation corresponding precisely to the negative effects on the species or habitat concerned*' (European Commission, 2007). Compensatory measures should achieve a benefit at least equivalent to the loss or damage incurred by the site's qualifying species. The results of compensatory measures should normally be in place before damage occurs to the site (SNH, 2014).

As identified from the data, two main aggregations of birds at key high tide roost locations (the breakwater area directly west of the Port of Grangemouth and the sheltered bay at the estuary edge north of the petrochemical plant) will potentially be affected during construction and maintenance of the Scheme. Therefore, compensation for the temporary disturbance of birds at these two sites is required.

To maintain the integrity of the European site network, compensation roosting habitat needs to provide alternative habitat for the duration of construction of the Scheme, and during operational phase maintenance activities, which is at least functionally equivalent to that which is potentially lost (SNH, 2014). This section details the proposed compensation requirements.

8.2 Design Considerations for Roosting Bird Habitats

High tide roost selection by birds is most strongly affected by the proximity to large foraging areas, field of view and, to a lesser extent, by composition of the surrounding landscape. Several factors must be considered when creating a high tide roost including predation risk (distance to tall vegetation, separation from the mainland, visibility), energetics (energetic cost travelling to and from site), disturbance risk and proximity to nearby feeding sites (Rogers, 2003). It is important that undisturbed roosts are close to the birds' main feeding areas, particularly in winter. A study carried out by Zharikov and Milton (2009) found that abundance of certain species, such as bar-tailed godwit and curlew, depended on distance to the nearest large foraging area or the size of the roost. A detailed survey on the provision of refuges for roosting waders was undertaken by Rehfisch et al. (1993) and was considered during this assessment. The compensation areas should involve creation of areas of ground of a suitable substrate, level, extent and position to attract roosting birds during the high tide period.

8.2.1 Compensation Site Selection Rationale

The rationale behind identification of suitable compensation sites is based on making provision for at least the losses incurred due to the Scheme. The breakwater roost is located west of the Port of Grangemouth. It is a linear feature comprised primarily of rock substrate, which channels the flow of the River Carron through the intertidal area of the Firth of Forth. The breakwater spans an area of approximately 0.9ha, some of which will be submerged at high tide. The sheltered bay roost is located in a corner of the intertidal area where a trapezoidal section of reclaimed land meets the perimeter of the petrochemical plant. This area is largely comprised of mudflat habitat with some fringing drier substrates backed by small areas of saltmarsh habitat.

Roosting birds could be disturbed from any location within the ZoI of the Scheme during construction works and operational maintenance activities, the most sensitive locations being at the breakwater and sheltered bay areas, as described. Phasing of construction works controls the potential for disturbance of roosting birds to occur at multiple locations simultaneously. In the event of a disturbance, roosting birds from one location/stretch of works could be affected and possibly displaced, not multiple groups of birds from several locations. Displaced roosting birds are anticipated to seek a nearby suitable alternative location at which to land and resume roosting behaviour, minimising the energetic cost involved.

The overriding consideration when identifying suitable compensatory roosting habitat location(s) is consequently proximity to the location at which the original disturbance is thought most likely to occur, whilst being sufficiently far from the source of disturbance for it to no longer be an effect. In order to minimise the distance through which displaced birds might need to travel, two locations have been identified for the implementation of compensation measures for the Scheme – Kinneil Lagoons to the east and Bothkennar Pools to the west. Provision of multiple compensation site locations also offers displaced birds options as opposed to reliance on the effectiveness of only one location, thereby providing a robust solution with embedded resilience.

Consideration was given to identifying possible compensation site locations elsewhere in the catchment, outside of the boundary of the Firth of Forth SPA (and beyond the ZoI of the Scheme), however the greater distances involved (compared to Kinneil Lagoons and Bothkennar Pools) was considered to significantly decrease the likelihood of displaced birds selecting these locations.

Avoidance of provision of compensatory measures within an SPA is typically adopted where functionally supporting habitats could be adversely affected, however the proposed works are either in areas which are currently non-functional for the qualifying features involved, or will significantly enhance the quality of existing habitat. Compensatory measures have been developed in close consultation with NatureScot experts.

At Kinneil Lagoons, four islands will be created within the lagoon and there will be some targeted tree and scrub removal on the area of land closest to the islands. At Bothkennar Pools, an area of land between two lagoons will be made more suitable for roosting birds at high tide by altering the shape of the land between the two lagoons and managing the vegetation. Detailed information on the compensation measures at Kinneil Lagoons and Bothkennar Pools is available in Section 8.3 and provided on Figure 34.

Table 8.1 identifies the suitability of the proposed compensation measures for the qualifying species of the Firth of Forth SPA.

This HRA considers that a 300m ZoI is suitable for noise disturbance for all qualifying species of the SPA and for visual disturbance for 18 of the 27 qualifying species. Additionally, a 650m ZoI for visual disturbance was implemented for nine species (common scoter, curlew, eider, golden plover, pink-footed goose, red-throated diver, scaup, shelduck and wigeon). To avoid implementing several ZoI, for the purposes of this assessment, the recommended visual disturbance buffer of the most sensitive species (650m for curlew) has been applied to all species with a recommended buffer of more than 300m. Therefore, the 650m ZoI is very precautionary for some of the nine species (e.g. eider and scaup) based on a review of the literature.

The compensation sites are located outwith the 300m ZoI but fall within the 650m ZoI for visual disturbance for the nine species previously identified. However, both sites are fully screened from construction works by existing vegetation and topography. More information is provided within Sections 8.3.1 Kinneil Lagoons and 8.3.2 Bothkennar Pools.

Table 8.1 Qualifying interest species requirements

Qualifying Interest	High Tide Roost Requirements	Suitable Compensation Provision	References
Bar-tailed godwit	Bar-tailed godwit often roost on sandy beaches, sandbars, spits and also in habitats in proximity to coastal saltmarsh. Birds have also been recorded roosting in wet grasslands and farmlands on occasion. Bar-tailed godwit typically roost on higher level sites, before the water level reaches the ankles of the birds.	The proposed compensation sites will provide suitable roosting habitat for bar-tailed godwit. At Kinneil Lagoons, four islands will be created which will be topped with gravel/crushed aggregate to mimic a shingle beach. The dome shape of the islands and gradual, sloped sides will enable bar-tailed godwit to roost at any time without leaving the area due to water level. At Bothkennar Pools, the sloping edges of the pools, reprofiling of the eastern embankment, and creation of a short sward will also provide suitable roosting habitat. Vegetation removal will occur at both locations to remove potential predator perches and cover.	McCaffery and Gill (2020) Gill and Handel (1990)
Curlew	Curlew roost in fields close to coastal habitats and will tolerate taller vegetation as they are relatively large wading birds, allowing for maintained predator vigilance.	The proposed compensation sites will provide suitable roosting habitat for curlew. At Kinneil Lagoons, four islands will be created which will have a mimic shingle beach sloping to the water's edge. At Bothkennar Pools, the sloping edges of the pools, reprofiling of the eastern embankment, and creation of a short sward will also provide suitable roosting habitat. Vegetation removal will occur at both locations to remove potential predator perches and cover.	Rogers (2003) Zharikov and Milton (2009) Van Gils et al. (2020)
Dunlin	Dunlin roost above or slightly below the high tide line with preference for relatively smooth/level surfaces of mud/sand/gravels. Roosting areas are generally open spaces to avoid predation risk. Dunlin roost in areas including sandbars, islands and coastal beaches.	The proposed compensation sites will provide suitable roosting habitat for dunlin. At Kinneil Lagoons, four islands will be created which will have a mimic shingle beach sloping to the water's edge. At Bothkennar Pools, the sloping edges of the pools, reprofiling of the eastern embankment, and creation of a short sward will also provide suitable roosting habitat. Vegetation removal will occur at both locations to remove potential predator perches and cover. As noted in this HRA, the roving flock of dunlin around Grangemouth are not site faithful and have several high tide roost locations.	Handel and Gill (1992) Rogers (2003) Zharikov and Milton (2009) Rehfisch (1993) Warnock and Gill (2020)
Golden plover	Golden plover are largely dependent on low-lying cultivated land, coastal mudflat, saltmarsh and rocky foreshore roosting in tight, compact assemblages.	The proposed compensation of four islands at Kinneil Lagoons and managed short sward habitat at Bothkennar Pools will provide suitable roosting habitat for golden plover, in addition to the vast expanse of tidal flats and arable land in the vicinity.	Wiersma et al. (2020)
Knot	Knot roost above or slightly just below the high tide line, with preference for sandy coastal habitats. They form dense aggregations on shorelines at high tide, often with dunlin.	The proposed compensation sites will provide suitable roosting habitat for knot. At Kinneil Lagoons, four islands will be created which will have a mimic shingle beach sloping to the water's edge. At Bothkennar Pools, the sloping edges of the pools, reprofiling of the eastern embankment, and creation of a short sward will also provide suitable roosting habitat. Vegetation removal will occur at both locations to remove potential predator perches and cover.	Rogers (2003) Zharikov and Milton (2009) Rehfisch (1993) Baker et al. (2020)
Lapwing	Roosting flocks of lapwing prefer spacious, old pastures as well as mudflats. They mainly roost on drier ground with clear viewsheds to avoid predation risks.	The proposed compensation of four islands at Kinneil Lagoons and managed short sward habitat at Bothkennar Pools will provide suitable roosting habitat for lapwing, in addition to the vast expanse of tidal flats and arable land in the vicinity.	Wiersma et al. (2020)

Qualifying Interest	High Tide Roost Requirements	Suitable Compensation Provision	References
Mallard	Mallard often roost on water or along vegetated fringes at high tide. They can roost above the high tide line, particularly to conserve energy when water temperatures drop significantly. They are less restricted in terms of vegetation state and specific roost site selection.	The proposed compensation sites will provide suitable roosting habitat at Kinneil Lagoons and Bothkennar Pools for mallard, both on water and vegetated fringing habitat during high tide, with expanses of water present at both sites and on the nearby Firth of Forth estuary.	Drilling et al. (2020)
Oystercatcher	Oystercatcher are communal roosters. They often roost on mud, sand, gravel or rocky coasts and estuaries. They also sometimes roost inland by lakes and rivers with low levels of disturbance and at a safe tide height.	The proposed compensation sites will provide suitable roosting habitat for oystercatcher at Kinneil Lagoons on the four islands that will be created, and along the pool edge and area of short sward at Bothkennar Pools.	Van der Kolk et al. (2021) Hockey et al. (2020)
Red-throated diver	Red-throated diver forage and roost on water close to shore in coastal estuaries over winter.	The proposed compensation sites will provide suitable roosting habitat at Kinneil Lagoons and Bothkennar Pools for red-throated diver, with expanses of water present at both sites and on the nearby Firth of Forth estuary.	Rizzolo et al. (2020)
Redshank	Redshank roost above the high tide line at secure roost sites. These tend to be open spaces to avoid predation, near to their feeding grounds, in sometimes dense aggregations. Redshank are often found as part of larger groups with dunlin.	The proposed compensation sites will provide suitable roosting habitat for redshank. At Kinneil Lagoons, four islands will be created which will have a mimic shingle beach sloping to the water's edge. At Bothkennar Pools, the sloping edges of the pools, reprofiling of the eastern embankment, and creation of a short sward will also provide suitable roosting habitat. Vegetation removal will occur at both locations to remove potential predator perches and cover.	Van Gils et al. (2020)
Ringed plover	Ringed plover choose shingle shores with stones of a specific size to allow some shelter without loss of visibility. Ringed plover roost near feeding areas, usually just above the high tide line.	The proposed compensation sites will provide suitable roosting habitat ringed plover. At Kinneil Lagoons, four islands will be created which will have a mimic shingle beach sloping to the water's edge.	Wiersma et al. (2020)
Wigeon	Wigeon forage and roost along the water's edge, together with teal and mallard, with some rafting taking place. They are often associated with roosting in brackish waters and near grass banks of lakes. Wigeon also roost close to feeding grounds, dabbling for shallow submerged vegetation and grazing on terrestrial grassland close to water.	There are suitable areas of open water available for this species to roost at both Kinneil Lagoons and Bothkennar Pools, with suitable pool edge created at Bothkennar Pools through the proposed habitat management.	Carboneras et al. (2020)

8.3 Compensation Proposals

8.3.1 Kinneil Lagoons

8.3.1.1 Background

Kinneil Lagoons is located between Grangemouth and Bo'ness (Figure 34) and is an important waterbird high tide roost within the inner Forth, attracting thousands of wintering birds such as knot, dunlin and black-tailed godwit each year. The site is part of the Firth of Forth SPA and Ramsar site and is owned by Falkirk Council. The lagoons were created when the intertidal zone was reclaimed in 1969, when a seawall was built along the seaward side as part of the Kinneil Kerse landfill site operation. The lagoons are linked to the Forth through a series of large pipes in the seawall, which allows sea water to come in and go out with each tidal cycle. The resulting saline lagoon/mud habitat is an uncommon habitat on the Forth (Inner Forth Landscape (IFL), 2019a).

The Scheme's data suggests that the lagoons are likely to be able to already support the numbers of roosting birds potentially displaced during construction from the sheltered bay (see Section 8.3.1.3 Kinneil Bird Numbers). However, to ensure that there is adequate high roosting habitat, compensation in the form of four islands will be created. Islands are known to be utilised by wading birds for roosting as they provide a protection from land-based predators and the edge habitat allows for birds to roost at different heights as required with the tidal cycles.

The proposed works outlined below would be separate, but complementary to, any site management plan which may be implemented by Falkirk Council prior to compensatory works commencing, and detailed design would be undertaken in consultation with Falkirk Council.

8.3.1.2 Compensatory Habitat

At Kinneil Lagoons, four islands will be created within the lagoons to provide new high tide roosting habitat for the qualifying species of the SPA (and any other roosting birds that may wish to utilise them). The largest island will be created from an existing 'spit' of land that extends from the southern side of the lagoons and the other three islands will be located to the north and east of this. Additionally, there will be some targeted tree and scrub removal close to the islands to provide good sight lines for roosting birds and remove potential predator perches (Figure 34).

Whilst the compensation site falls within the 650m ZoI for visual disturbance for the nine species previously identified, it is fully screened from construction works by existing vegetation and topography. At Kinneil, the lagoons are located in a basin, with higher ground surrounding it on all sides, and there is a bund that runs along the east and south perimeter (Photograph 8.1). To the southwest of the lagoons, woodland and scrub screens the site from the existing access road (Photograph 8.2).

Photograph 8.1: Looking northeast from a passing bay on the access road to Kinneil Kerse waste water treatment facility. The bund and higher ground with scattered trees are visible on the other side of the field, and the area of woodland is visible to the left.

Photograph 8.2: Looking southeast from a passing bay at the bend in the access road to Kinneil Kerse waste water treatment facility. The woodland edge is visible to the left and a bund is visible above the field.

There are no footpaths or easy means of access that would bring members of the public close to the spit at the southeast side of the lagoons. The spit currently comprises large pieces of concrete rubble and building debris, with scattered scrub and a thin layer of grass over the rubble and is not utilised by roosting birds (Photographs 8.3 to 8.5).

Photograph 8.3: Spit of land at Kinneil Lagoons which is has a perimeter of concrete blocks/rubble.

Photograph 8.4: The spit of land is composed of large pieces of concrete rubble.

Photograph 8.5: A thin layer of soil and grass covers the concrete rubble with some scattered scrub.

Creation of four islands would provide approximately 0.62ha of roosting habitat, although this would vary to a limited extent with the changing lagoon water levels. The approximate area of each island is as follows:

- Island 1: 0.33ha
- Island 2: 0.05ha
- Island 3: 0.14ha
- Island 4: 0.09ha

Construction of the islands will take place in the spring/summer months, outwith the most sensitive period for the qualifying species of the SPA (October to March inclusive). Works will be cognisant of the tide times at Kinneil Lagoons and will not take place at high tide. The existing spit will be used to create a haul road/causeway to enable the new islands to be created (islands 2 to 4).

All islands will have a domed surface, sloping to the water's edge in a 1:50 gradient, which will ensure no steep banks. The centre of the islands will be approximately 1.00m AoD, slightly higher than the edges, and will be designed so that the islands will inundate rarely during extreme flood events or the highest spring tides. The islands will have indented bays, to varying extents, which will increase edge length and is more attractive to roosting birds. Islands 2, 3 and 4 will be created from aggregate/crushed rubble and covered in a geotextile membrane to supress vegetation growth. The membrane will be buried at least 200mm below the surface and firmly fixed in place. The islands will then be topped with aggregate/crushed rubble approximately c. 25mm-100mm in size, which will mimic a shingle beach. This smaller aggregate/crushed rubble will form a layer 10-15cm deep and will be spread evenly to avoid creating any depressions which may fill with water and become unusable for roosting.

Island 1 will be created from the existing spit and the island level will be lowered to approximately 1.00m AoD. The rubble which comprised the spit will be crushed to create the heart shape of island 1 and the topsoil of the

spit would be stripped. The geotextile membrane and smaller aggregate would then be laid in line with the process identified for all islands. If the crushed rubble is unsuitable or more is required than is crushed, suitable inert aggregate will be locally sourced and imported to site.

The final phase of creating island 1 will be to form a channel between the spit and the surrounding habitat. This will prevent terrestrial predators and dogs from accessing island 1 and then consequently the other islands. A deep channel will be excavated to 1.50m AOD to disconnect the island from Kinneil Lagoons boundary.

It is anticipated that all rubble and spoil excavated will be re-used to create the islands. Should any material need to be removed from site, the appropriate consents will be sought to do so.

The islands at Kinneil will be constructed and available for use by roosting birds at least one winter prior to construction works commencing adjacent to the Firth of Forth estuary. This is to ensure that compensatory habitat is in place before the commencement of potential disturbance impacts during construction.

8.3.1.3 Kinneil Bird Numbers

The Scheme compensation measures need to be large enough to support all roosting birds potentially disturbed by the works (SPA qualifying species and non-qualifying species), *in addition to* the number of birds which are already known to use the locations at which the compensation measures are proposed.

For Kinneil Lagoons, bird data from the survey period encompassing the winters of 2015/2016, 2016/2017 and 2022/23 was used to inform an assessment of how many birds may be displaced during construction and maintenance works. The working assumption adopted is that the worst-case scenario, in terms of numbers of roosting birds potentially displaced due to disturbance effects from works, would involve the large aggregations of birds in the sheltered bay area taking flight and moving to Kinneil Lagoons to roost, in addition to birds which might already be using the lagoon as a roost site. Birds displaced from the other main area holding large aggregations of roosting birds, namely along the breakwater, could similarly choose Kinneil Lagoons as their alternative roosting location, but works will not take place at both locations (breakwater and sheltered bay) simultaneously. Numbers of birds using the sheltered bay area are higher than at the breakwater, therefore we use the sheltered bay numbers in this analysis to represent the worst case for the purpose of sizing the compensatory habitat proposal in Kinneil Lagoons.

Typical roosting densities of birds were explored using available literature and evidence to determine if the proposed islands would provide adequate habitat spatially for displaced birds, additional to birds already using the lagoon as a roost site – details of which are described below.

Table 8.2 presents the summed peak counts of all qualifying and non-qualifying species recorded roosting within the sheltered bay and Kinneil Lagoons each month during the survey period. Certain species (common scoter, curlew, eider, golden plover, pink-footed goose, red-throated diver, scaup, shelduck and wigeon) are deemed to have a visual disturbance ZoI of 650m from the Scheme, and as such records up to the 650m ZoI boundary are included for these species, if present.

Table 8.2: Summed peak counts of all species (qualifying and non-qualifying species) recorded roosting at Kinneil Lagoons and the sheltered bay area each month. The highest counts recorded are demarcated by bold cell outlines.

	2015		2016		2017		2022		2023	
	Sheltered Bay	Kinneil Lagoons	Sheltered Bay	Kinneil Lagoons	Sheltered Bay	Kinneil Lagoons	Sheltered Bay	Kinneil Lagoons	Sheltered Bay	Kinneil Lagoons
January	n/a	n/a	2,496	7,522	**17,217**	**10,500**	n/a	n/a	1,122	2,560
February	n/a	n/a	1,030	5,930	2,387	2,057	n/a	n/a	966	436
March	n/a	n/a	198	7,874	727	5,420	n/a	n/a	720	1,392
August	404	1,780	n/a	1,409	n/a	n/a	1,606	1,986	n/a	n/a
September	1,073	1,779	1,581	2,232	n/a	n/a	2,547	2,337	n/a	n/a
October	1,182	1,225	2,601	5,574	n/a	n/a	2,049	527	n/a	n/a
November	947	4,663	6,375	428	n/a	n/a	1,311	2,344	n/a	n/a
December	717	7,998	7,381	9,924	n/a	n/a	1,797	1,686	n/a	n/a

Dunlin was the most abundant species recorded during the surveys at each site. Dunlin made up over 50% of the total species count on several occasions within Kinneil Lagoons. A maximum flock size of 11,000 birds was recorded in January 2017 roosting at high tide in the sheltered bay (survey Sector 9) (Appendix B: Ornithological Information). Dunlin tend to move between several roost sites frequently in large numbers (Conklin and Colwell, 2007) and it is likely that the peak number of birds recorded in the sheltered bay in January 2017 contains birds which were also recorded in Kinneil Lagoons in the same month (on different days).

Adopting a highly precautionary approach however, the worst-case scenario for birds potentially needing to use Kinneil Lagoon as a roost site (if displaced by works) could at times be as high as the combined numbers observed in January 2017, i.e. 17,217 + 10,500 = 27,717 birds. The compensatory measures therefore need to accommodate at least that number, plus a contingency to allow for years when numbers of birds using these areas could be even higher than those recorded during the study period.

Dunlin and knot are known to form densely packed roosts (Baker et. al, 2020; Warnock and Gill, 2020). Literature on roosting densities of waders is limited; however, Cramp and Simmons (1983) studied the high tide roosting behaviour of dunlin on saltmarsh and noted a maximum density of 20 birds per m^2. Knot are known to roost in denser aggregations than dunlin. However, other larger wader species, such as redshank and bar-tailed godwit present within the sheltered bay, roost less densely.

Published literature regarding roosting densities of the majority of species present within the sheltered bay/ZoI of the Scheme is extremely limited. A figure of 5 roosting bar-tailed godwit per m^2 is noted in McCaffrey and Gill (2020). However, using professional judgement and experience of observations of roosting birds at multiple schemes, an understanding of the other species' roosting densities can be achieved. In general, all other terrestrial roosting species roost at lower densities in comparison to knot and dunlin, with some species more frequently found to roost on water i.e. shelduck, mallard and teal (Toomer and Clark, 1992) and therefore more likely to use the main lagoon waterbody. Although the majority of potentially displaced birds are dunlin and knot which form dense roost aggregations (circa 20 birds per m^2), a precautionary density figure of 10 birds per m^2 for small – medium wader species and 5 birds per m^2 for larger wader and duck species based on professional experience would suitably account for all potentially displaced species roost densities. Seven small to medium sized wader species (dunlin, golden plover, knot, redshank, lapwing, oystercatcher and ringed plover) and seven large wader and duck species (bar-tailed godwit, black-tailed godwit, curlew, mallard, shelduck, teal and wigeon) were recorded in large aggregations within the sheltered bay area during the bird surveys. Using the precautionary 5 birds per m^2 and 10 birds per m^2 roost density figures this results in an overall average roost density figure of 7.5

birds per m^2. This figure is considered sufficient to accommodate all species displaced however it is expected that dunlin and knot will comprise the majority of the potentially displaced flock.

The total area of the proposed islands once created would be approximately 6,184m^2 (0.62ha). Using the precautionary roosting density figure of 7.5 birds per m^2, the Kinneil islands group could therefore provide an additional theoretical capacity to accommodate 46,380 roosting birds, which is comfortably above the estimated maximum number of 27,717 birds described above, providing a buffer sufficient to give confidence that the proposed compensatory measures are proportionate to the effect and will secure the long-term integrity of the European Sites Network.

8.3.1.4 Site Investigations

Investigation undertaken at the Kinneil Lagoons consisted of surface water sampling which was undertaken on 21st October 2020 at two separate locations and on 10th November 2020 at three locations (including the initial two). The purpose of this was to review the chemical properties of the lagoon, as well as the potential for groundwater discharges from the Kinneil Kerse landfill into the lagoon, which could impact on the lagoon's surface water quality.

The samples were tested for a range of metals, inorganics and organics. The results were screened against both the freshwater and marine Environmental Quality Standard (EQS). There were elevated concentrations of chloride and sulphate, which are likely to be attributed to the salinity of the surface water present due to the site's proximity to the Firth of Forth.

There is a possibility of the leaching of onsite anthropogenic materials and natural sediments into the surrounding tidal lagoon surface water, and subsequently underlying groundwater. However, there is likely to be substantial dilution and dispersion.

8.3.1.5 Consents

The proposal has been agreed with Falkirk Council, who own the land at Kinneil Lagoons.

SEPA confirmed on 20 December 2021 that a waste management licence will not be required as material will not leave the site.

As works will take place below the tidal level of Mean High Water Springs (MHWS), a marine licence will be required. This will be applied for prior to construction of the island at Kinneil Lagoon. Creation of the compensatory habitat will be assessed as part of the Scheme marine licence application.

8.3.1.6 Maintenance and Monitoring

Longer term management of the islands will be required during construction and operation of the Scheme to ensure the island remains a shingle surface to encourage roosting birds. If the islands become heavily vegetated with dense vegetation this will discourage some birds, particularly waders, from roosting. As a geotextile membrane to supress vegetation growth will be laid, maintenance of the compensatory habitat to keep vegetation levels low should be minimal. On completion of the Scheme, the compensatory habitat will be managed by Falkirk Council or in agreement with another appropriate stakeholder.

The employer's ecologists will monitor bird use of the site for an appropriate number of winters following completion of the compensation measures and throughout construction of main works adjacent to the Firth of Forth SPA/Ramsar site.

8.3.2 Bothkennar Pools

8.3.2.1 Background

Bothkennar Pools lie between Skinflats Village to the east and the River Carron to the south (Figure 34). The site is part of the Firth of Forth SPA and Ramsar and is noted within the Falkirk Area Biodiversity Action Plan. The land is owned by Falkirk Council and the site has benefitted from some management by Falkirk Council Biodiversity

Officers, such as tree planting at targeted areas around the perimeter and the installation of tern rafts on the northern pool. Bothkennar Pools features both saline and freshwater lagoons which formed due to subsidence caused by past undermining of the land. The saline lagoon (the southern pool, closest to the River Carron) and reed beds are slowly increasing in size due to this subsidence (IFL, 2019b).

This site could support displaced birds during construction and maintenance works from the high tide roost along the breakwater given its close proximity and suitable habitat. The site is known to already contain high tide roosts which are currently infrequently used by most species recorded or used in low numbers. It is likely that the current vegetation (including scrub, rushes, and a line of trees) makes the site less attractive to birds as it hinders sight lines. The proposed works outlined below would be separate, but complementary to, any site management plan which may be implemented by Falkirk Council prior to compensatory works commencing, and detailed design would be undertaken in consultation with Falkirk Council.

8.3.2.2 Compensatory Habitat

At Bothkennar Pools, the site is fully screened from works on the right bank of the River Carron by a large bund (approximately 3-4m in height from the existing access track) on the left bank of the River Carron, which is lined with scattered trees (Photographs 8.6 and 8.7).

Photograph 8.6: Photograph is looking southeast from field edge, adjacent to public footpath. The bund (approximately 3-4m high) on the left bank of the River Carron is lined with scattered trees and scrub.

Photograph 8.7: Photograph is looking southeast from the field, between the two pools. The bund and line of trees is visible in the background.

Public core paths surround Bothkennar Pools but are not present through the area of land between the two pools. Core paths are screened from the pools; the core path along the west side of the pools is screened by vegetation (IFL, 2018) and the path to the east is behind a bund approximately 1m high. The pools are fenced off from the public, including the area proposed for compensation, and fencing will be retained to restrict public access. The area currently comprises poor semi-improved grassland, rushes, reeds and scattered scrub.

Photograph 8.8: Location of compensatory habitat between the two pools at Bothkennar. Photograph is looking southwest from the east of the land between the pools.

At Bothkennar Pools the area of land between the two pools (Photograph 8.8 and Figure 34) will be managed to become more appealing to roosting birds. Approximately 2.90ha of roosting habitat will be available to fully compensate for birds displaced from the breakwater, which has an area of 0.9ha.

Evidence of birds roosting in similar habitat has been observed at the Musselburgh lagoons in East Lothian, which are also part of the Firth of Forth SPA and Ramsar site. Photograph 8.9 shows qualifying species of the sites roosting on an area of grassland in between two pools at Musselburgh lagoons.

Photograph 8.9: Birds roosting on land in between the Musselburgh lagoons. Photograph taken on 23 April 2019.

At Bothkennar Pools, the shape of the land between the two lagoons will be altered to create more edge habitat for roosting birds. An area on each side of the lagoon will be excavated and this material will be used to the create spits of land that encroach into the pools. The topsoil removed from the excavated areas will be laid on the new areas created.

The existing habitat will be made more suitable for high tide roosting by removing the scrub vegetation and maintaining a short sward length (c. 50mm) through the winter months (September-March). Rushes, which have become dominant in this area, will be cut and maintained to provide a more open area of grassland for roosting birds. Grazing of this area currently takes place between April and September (inclusive) by a small herd of cattle (maximum 13 livestock) as permitted by Falkirk Council and NatureScot. Grazing throughout these months helps to maintain a short sward grassland, which is attractive to roosting birds as it provides an open area from which the birds' view of the surrounding area is unobstructed, thereby enabling early detection of predators. Cattle are not permitted within approximately 5m of the edge of the northern pool to prevent cattle damage and over grazing in this area. This area will be managed manually.

Reed growth, particularly within the southern pool, has reduced the area available for feeding and increased cover for predators, which may be inhibiting birds from using the pool. Cutting and removal of reeds from both pools will also be undertaken to make the area more attractive to feeding and roosting birds. With the current grazing regime continuing, and management of scrub, rushes and reeds, it is considered that the area would become attractive and suitable for roosting birds.

The habitat management at Bothkennar will be completed and available for use by roosting birds at least one winter prior to construction works commencing adjacent to the Firth of Forth estuary. This is to ensure that compensatory habitat is in place before the commencement of potential disturbance impacts during construction.

8.3.2.3 Site Investigations

Ground investigations consisting of six hand dug pits (to a maximum depth of 1.2 m below ground level) were undertaken on 30th September 2020 in order to assess ground conditions and confirm the presence of any made ground and the nature of any potential contamination within the site. Environmental soil samples were taken from all hand pits. The ground conditions encountered generally comprised a layer of shallow topsoil between 0.1m and 0.4m in thickness above either slightly sandy slightly gravelly clay or silt. One location comprised silty clay above fine to coarse gravel containing slag like material (made ground) which was first encountered at 0.9 m below ground level.

Seven soil samples were tested for a range of metals, inorganics, pesticides and organics. The samples were screened against generic assessment criteria (GAC) including S4UL, EIC and C4SL to assess the potential risks to human health. No exceedances were recorded for any of the samples.

Two rounds of surface water sampling were undertaken on 21st October 2020 and 19th November 2020, with samples taken from three locations. The purpose of this was to review the chemical properties of the pools and the associated water quality. The samples were tested for a range of metals, inorganics and organics. The results were screened against the freshwater and marine Environmental Quality Standard (EQS).

There is a possibility of the leaching of onsite anthropogenic materials and natural sediments into the surrounding pools and subsequently underlying groundwater. However, whilst there is reclaimed land beneath the pools, there is no evidence to suggest that this is significantly contaminated and there is likely to be substantial dilution and dispersion.

8.3.2.4 Consents

The compensation proposal will be agreed with Falkirk Council and permission obtained prior to creation. The Scheme has liaised with Falkirk Council to ensure that the compensation measures are complimentary to the current site management activities.

8.3.2.5 Maintenance and Monitoring

The scrub, rushes and reeds will be maintained, at least annually, to keep growth to a minimum and provide an open area of grassland. If required on top of the current grazing regime, maintenance to keep the grass to a suitable height will take place annually as a minimum, for example the area will be mown in autumn to create suitable roosting habitat ahead of the overwintering period. On completion of the Scheme, maintenance as described will be co-ordinated by Falkirk Council.

The employer's ecologists will monitor bird use of the site for an appropriate number of winters following completion of the compensation measures and throughout construction of main works adjacent to the Firth of Forth SPA/Ramsar site.

8.4 Compensation Conclusion

As it may not be possible to demonstrate beyond reasonable scientific doubt that the project will not adversely affect the integrity of the Firth of Forth SPA and Ramsar as a result of disturbance to birds roosting at high tide during construction and maintenance works, compensatory measures have been identified to support displaced birds.

Kinneil Lagoons are currently very popular with roosting birds. It is considered that the proposed compensation would enhance the site by enabling it to support even higher numbers of birds, which may be displaced from nearby high tide roost(s).

Bothkennar Pools, although used by birds, are infrequently used by most species for roosting. The proposed compensation would enhance the habitat already designated as part of the SPA and provide suitable roosting opportunities to compensate for the displacement of birds from the high tide roost(s).

In summary, the compensatory measures ensure the overall coherence of the European Sites Network by achieving the following:

Effectiveness

- The compensatory measures proposed involve creation of new islands at Kinneil lagoon and improvement of roosting habitat at Bothkennar Pools. Waterbirds are a well-researched and understood species group, whose habitat requirements are well documented. The best roost sites are undisturbed, close to feeding grounds, protected from prevailing winds, offer easy access to water at the edge of the roost, and have limited or no vegetative cover – all of these features are provided in the designs of the proposed measures. Further, islands

are known to be especially attractive to waterbirds as they reduce the risk of predation of roosting birds from land predators and typically offer good all-round views, again allowing birds to spot predators at distance. The chosen locations are already utilised by roosting birds – the proposals add to the capacity of each location and enable these areas to support greater numbers. The compensatory measures will therefore be effective in their purpose of attracting and supporting roosting birds.

Feasibility

- The proposed measures are designed to be easily constructed. Creation of new islands at Kinneil and reprofiling of land/water edges at Bothkennar Pools involve relatively simple earthworks, placing of material and profiling, with no complex construction methods required. There will be no requirement for export of materials during the works, making use of existing on-site materials where possible. Vegetation management at Bothkennar is a basic land management task, involving simple, tried and tested methods. The site investigation works did not identify the presence of any contaminants at unsafe levels. Both compensation sites are located on Falkirk Council land, who are content for the proposed measures to be implemented as part of the Scheme. Liaison with other relevant stakeholders will continue as required.

Best practice

- A key aspect of the selection of the location of the measures, both at Kinneil and at Bothkennar, is that they are close to the source of potential disturbance and close to the birds' foraging areas. Best practice design is to provide sufficient suitable roosting habitat matching these criteria. Displaced birds will not have to fly far to find the alternative roosting habitat, and the roost locations are close to existing known foraging areas. Data gathered on numbers of birds using the Scheme area have been used to calculate the required area/extent of roosting habitat required to accommodate the potential number of displaced birds.

Proportionate

- Following the precautionary principle, the HRA identifies a potential adverse effect on site integrity arising from temporary disturbance of roosting birds. The proposed measures are designed to attract and support roosting birds, using best practice methods and scientific knowledge. Each location on its own could theoretically support the number of potentially displaced birds during works (as identified in Section 8.3.1 Kinneil Lagoons), but a 'belt-and-braces' approach has been adopted in proposing compensatory measures at two separate locations. The proposals are therefore robustly proportionate to the identified effect.

Delivery timing of Compensation Measures

- The proposed measures will be in place at least one winter prior to the commencement of works adjacent to the estuary.

Safeguard the overall coherence of the European Sites Network

- Waterbirds breeding in Arctic areas use UK estuaries during passage and winter periods. UK estuaries are globally important in this respect. Birds can move around/between estuaries through the winter period, depending mainly on cold weather conditions, food availability and levels of disturbance. Therefore, it is essential to maintain a network of suitable sites, offering sufficient foraging resource and roosting habitat which is not excessively disturbed. The proposed compensatory measures, by providing increased habitat for roosting birds in perpetuity, will therefore help to safeguard the overall coherence of the European Sites Network.

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