Defence Infrastructure Organisation

Dalgety Bay

Management Strategy
DIO Project No 12920

Final Report

7 July 2014

Prepared by AMEC Environment & Infrastructure UK Limited for the Ministry of Defence, under commission GPS/ELMG/088

Report for

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Executive Summary

Purpose of This Report

The Defence Infrastructure Organisation (DIO) has been assisting the Scottish Environment Protection Agency (SEPA) with their inspection of land and foreshore at Dalgety Bay. As part of this support to SEPA, DIO commissioned AMEC Environment and Infrastructure UK Ltd (AMEC) to develop a Management Strategy.

This report sets out the Management Strategy and associated outline performance specification to address risks from radium contamination within specific areas of the Dalgety Bay foreshore as part of DIO's contribution to the Dalgety Bay Implementation Group.

Background

SEPA has identified potential significant pollutant linkages (SPLs) on specific areas of the Dalgety Bay foreshore associated with the presence of radium contamination. The potential significant pollutant linkages describe the risks presented to the public (beach users) from identified radium contamination via dermal contact and inadvertent ingestion by intrusive and non-intrusive activities on the foreshore. The risk assessment developed by SEPA has been reviewed as a part of the more detailed assessment undertaken by Eden Nuclear on behalf of DIO.

SEPA has sought advice from Public Health England (PHE) regarding health protection criteria with respect to the management of identified radium contamination. PHE has advised the following criteria:

For the avoidance of exposures above a specified level of dose:

- Criterion 1: That all efforts should be made to ensure that objects that could give rise to a committed effective dose of 100mSv to an individual, regardless of object size, or an external dose of 1 Gy h^{-1}, averaged over an area of $1cm^2$ skin at a depth of 70 microns, are either removed or isolated so that there is no credible current or future mechanism for exposure; and

For optimisation, a lower bound below which explicit demonstration of ALARA (as low as reasonably achievable) is not required on radiation health grounds:

- Criterion 2: That radium contaminated objects remaining after application of Criterion 1 should be either removed or isolated so that the current or future probability of an individual receiving a 1 mSv committed effective dose is less than 10^{-6} per year. In addressing this criterion, optimisation should be carried out so that increasing weight is given to management options that remove or isolate objects of increasingly high activity.

The overarching objective of this Management Strategy, taking account of the more detailed Risk Assessment and the PHE criteria, is to identify and develop a recommendation for an effective long-term management strategy for the mitigation of risks from radium within the foreshore that is both practicable and sustainable.

Process Adopted

An Outline Management Options Appraisal (OMOA) was developed in January 2014 to mitigate the risks from the potential SPLs identified by SEPA. The OMOA identified four broad outline management approaches comprising: exclusion of receptors, cover system/encapsulation, excavation and disposal and an optimised approach comprising a number of techniques.

These four approaches have been explored to generate a wide range of potential management strategy options to address the risks from foreshore radium contamination. These management strategy options have been assessed through a tiered scoring process, in line with good practice, to define an overarching Management Strategy.

Management Strategy

The Management Strategy which has been adopted to address the risks from radium contamination in areas identified by SEPA as having potential SPLs comprises:

1. Installation of rock armouring in areas where this is currently absent to mitigate against the loss of known landward radium contamination into the foreshore environment;
2. Replace/reinforce existing coastal armour protection to mitigate against the loss of landward radium contamination into the foreshore environment;
3. Removal of high activity (>40 kBq) radium materials from selected accessible foreshore areas; and
4. Limited reprofiling of foreshore and placement of rock armour cover system to isolate remaining radium contamination.

By securing the landward radium contamination (Items 1 and 2), future mechanisms for radium repopulation onto the foreshore will be mitigated. In combination with the removal of high activity (>40 kBq) materials (Item 3), Criterion 1 will be satisfied.

The extension of rock armouring over the foreshore (Item 4) will prevent inadvertent contact with the residual lower activity radium contamination to satisfy Criterion 2. The covering of the foreshore would extend from the headland south-west of the Sailing Club around to the northern part of the Boat Park Bay area.

Implementation

In order to implement the overall Management Strategy, there are a number of consents, approvals and licenses that must obtained, with planning and environmental impact assessments likely to be required.

In the interim, there may be opportunities to progress small scale betterment, where planning permission may not be needed. This could include the removal of landward radium contamination and installation of rock armouring along a small exposed section along the north of the Boat Park. The landward radium contamination is currently vulnerable, being eroded by coastal processes and repopulating the foreshore with higher activity materials.

The main management strategy works would need to be completed in a series of phases over at least two summer periods working round from the headland to Boat Park Bay North.

Implementation Practicalities / Limitations

The timely detailed development and implementation of the Management Strategy is dependent upon a number of key enablers which necessitate a strong collaborative approach between key stakeholders. These include:

- A Management Strategy implementation approach agreed with key stakeholders. This broad requirement includes:
- Agreement on roles and responsibilities, especially with SEPA and Fife Council as key regulators;
  - Collaborative working through the Implementation Group (DIO, SEPA, Fife Council and landowners) during the detailed design development (e.g. the nature and extent of armouring, detail of replacement slipway, etc.); and
  - Basic necessities for implementation, such as landowners facilitating site access.
- Timely provision of the necessary permits, consents and licences through the SEPA Permitting Group with SEPA acting as the co-ordination body for the applications;
- A proactive and responsive planning environment. This is particularly important given the potential programme limitations to implementation from the various ecological designations;
- Availability of disposal routes for differing radium waste streams to be confirmed prior to and during implementation; and
- Confirmation of roles and responsibilities regarding the downstream maintenance and routine monitoring and agreement of the verification criteria.

Glossary of Terms

ACM	-	Asbestos Containing Material
ALARA	-	As Low As Reasonably Achievable
AOD	-	Above Ordnance Datum
CEM	-	Conceptual Exposure Model
CSM	-	Conceptual Site Model
DE	-	Defence Estates
DBPAG	-	Dalgety Bay Particles Advisory Group
DEFRA	-	Department for Environment, Food and Rural Affairs
DIO	-	Defence Infrastructure Organisation
DQRA	-	Detailed Quantitative Risk Assessment
FCP	-	Fife Coastal Path
LQA	-	Land Quality Assessment
MHWN	-	Mean High Water Neap
MLWN	-	Mean Low Water Neap
MHWS	-	Mean High Water Spring
MLWS	-	Mean Low Water Spring
MOD	-	Ministry of Defence
NGR	-	National Grid Reference
OMOA	-	Outline Management Option Appraisal
OS	-	Ordnance Survey
PHE	-	Public Health England
PPE	-	Personal Protective Equipment
RNAS	-	Royal Naval Air Station
SEPA	-	Scottish Environment Protection Agency
SG	-	Scottish Government
SoR	-	Statement of Requirements
SPL	-	Significant Pollutant Linkage

Contents

1. Introduction

1.1 Terms of Reference

The Defence Infrastructure Organisation (DIO) has been assisting the Scottish Environment Protection Agency (SEPA) with their inspection of areas of land and foreshore at Dalgety Bay in order to:

- Identify significant pollutant linkages[1] (SPLs);
- Examine the level of risk to human health; and
- Evaluate the need for, and scope of, any further work, including remediation associated with the presence of radium.

As part of this support to SEPA, DIO commissioned AMEC Environment and Infrastructure UK Ltd (AMEC) to develop a Management Strategy (this report) for radium contamination (Ra-226) identified on and within the foreshore of Dalgety Bay following identification of potentially significant pollutant linkages by SEPA (SEPA, 2012). The SEPA risk assessment has been reviewed as a part of the more detailed assessment of risk undertaken by Eden Nuclear and Environment on behalf of DIO.

DIO has consulted with SEPA during the development of this Management Strategy, which is informed by the Outline Management Options Appraisal prepared by AMEC in January 2014 (AMEC, 2014a).

The Management Strategy has been developed with particular reference to:

- Model Procedures, SAFEGROUNDS and other pertinent good practice guidance;
- The Conceptual Model and the nature and distribution of radium contamination in each bay area has been developed from the on-going monitoring, recent intrusive investigation and subsequent risk assessment;
- The particular current physical conditions of the foreshore and current coastal protection measures; and
- The tidal conditions and coastal processes.

This report sets out the Management Strategy and associated outline performance specification to address risks from radium contamination within specific areas of the Dalgety Bay foreshore as part of DIO's contribution to the Dalgety Bay Implementation Group.

[1] Pollutant linkages are defined in Section 3.2 of this report.

1.2 Objectives

DIO provided a Statement of Requirements (SoR) which formed the basis for this Management Strategy report.

The overarching objective of this Management Strategy, taking account of the more detailed Risk Assessment and the PHE criteria, is to identify and develop a recommendation for an effective long-term management strategy for the mitigation of risks from radium within the foreshore that is both practicable and sustainable.

1.3 Reference Documentation and Key Requirements

The following Table 1.1 provides a summary on the main reference documentation with, where applicable, key requirements for the Management Strategy that provide the framework by which this report has been developed. Where appropriate the key requirements are further expanded upon within this report.

Table 1.1 Reference Documentation

Document Owner and Reference	Key Information / Requirement	Action Taken
SEPA Appropriate Persons Report (SEPA, 2013)	Areas where potential SPLs have been identified	The Management Strategy has been developed with respect to specific areas of the Dalgety Bay foreshore identified by SEPA as having potential SPLs and with consideration of areas which are still under review by SEPA.
DIO Statement of Requirements (DIO, 2014)	Long Term Solution (+25 years)	The Management Strategy has considered appropriate solutions that meet, as a minimum, the specified longevity requirement.
	Effective	An assessment of the Management Strategy's performance has been compared to the defined health protection criteria in to demonstrate compliance.
	Practical	The practicality of implementing the potential Management Strategy has been considered ensuring technically achievable options can be delivered within a reasonable timeframe.
	Proportionate	The Management Strategy has been assessed for its overall benefit, including broader sustainability measures (social, environmental and economic).
PHE Radioactive Contamination at Dalgety Bay (PHE, 2014)	Criterion 1 – removal or isolation of radium that could give rise to a committed effective dose of 100 mSv so that there is no credible current or future mechanism for exposure.	The Management Strategy has been assessed with respect to PHE Criterion 1 in order to derive effective options. This is further discussed in Section 2.4.1.
	Criterion 2 – remaining radium following application of Criterion 1 should be removed or isolated so that current or future probability of an individual receiving 1 mSv committed dose are less than 10^{-6} per year.	The Management Strategy has been assessed with respect to PHE Criterion 2 in order to derive effective options. This is further discussed in Section 2.4.1.

This Management Strategy report has been developed with reference to the above reference documentation and the following technical reports:

- Stage 2 Intrusive Investigation Interpretative report (AMEC, 2014b) – draft in preparation; and
- Detailed Quantitative Risk Assessment (Eden, 2014) – draft in preparation.

In developing the Management Strategy for radium present within the foreshore, the focus has been on those areas identified by SEPA as either having, or may have (subject to further review) potential SPLs that are capable of meeting the criteria for Radioactive Contaminated Land broadly defined by SEPA as:

"*Radium sources within beach environment which are close to surface and can be encountered by the public via direct contact*" (SEPA, 2013).

The potential SPL pathways described by SEPA are: dermal contact and inadvertent ingestion.

Landward contamination and foreshore areas to the north of Boat Park have not been identified by SEPA as land that could be capable of meeting the definition of Radioactively Contaminated Land. The areas considered in this report are discussed in Section 1.4.

1.4 Site Definition

For the purposes of this Management Strategy, the Site, where referenced throughout this report, comprises the foreshore and one localised landward area as bounded in red on Drawing 1. The Site has been derived from areas where SEPA has either identified potential SPLs or are undertaking further review, together with the area subject previous work undertaken in accordance with the Dalgety Bay Inspection and Investigation Plan (DIO, 2012). In addition, consideration has been given to the foreshore geography/topography, soil type, tidal activity and, most importantly, the presence and distribution of radium distribution.

1.4.1 SEPA Areas

SEPA has divided the foreshore into six distinct areas, referenced Area A to H as shown on Drawing 1. This report considers the following areas:

- Areas C (Boat Park North), D (Boat Park South) and E (Slipways) where potential SPLs were identified by SEPA; and
- Areas B (Ross Plantation) and F (Headland) which are under further review by SEPA.

The remaining SEPA defined areas, Areas A, G and H do not have potential SPLs and are not under review. These are not considered further in this report.

1.4.2 Management Strategy Areas

The Management Strategy areas that comprise the Site and that are referenced within this report are defined below in Table 1.2.

Table 1.2 Management Strategy – Area Reference

Management Strategy Area	Descriptor	SEPA Area/Comment
Area H	Headland area	Includes the majority of Area F and the south-western third of Area E up to the jetty. This takes into account both radium distribution (as shown on Drawing 2) and similarity in ground conditions (including elevation) of the foreshore to the south-west. The significant rock outcrop in the west of Area F forms the boundary of this area.
Area S	Slipways area	Includes the remainder of Area E, extending north-easterly to, and including, the promontory rock outcrop.
Area BS	Boat Park Bay South	Area D.
Area BN	Boat Park Bay North	Area C and a southern segment of Area B to accommodate a distinct zone from the end of the rock armouring to the northern boundary of Area BN, referenced as Sub-Area BN-Z.
Area RP	Ross Plantation	The majority of Area B.

The distribution and activity of radium was an important consideration when defining the Management Strategy areas.

Ross Plantation

The ongoing monitoring surveys have not identified radium items in excess of 40 kBq (equivalent to PHE Criterion 1 as detailed in Section 2.4.1) in the Ross Plantation foreshore, to the west of the Management Strategy Area BN (Boat Park North). One radium find in excess of 40 kBq was recovered from the eastern most extent of SEPA Area B (which is described as Ross Plantation) but the location of this find is captured within the Management Strategy Area BN.

Additionally, no items in excess of 40 kBq were recovered during the 2012 site investigation of Ross Plantation and associated foreshore area. As such, it is considered unlikely that there is a substantial ongoing source of high activity material within the landward material in this area. The source of radium contamination in the Ross Plantation area is likely to be from the updrift areas comprising the Boat Park North, Boat Park South, Slipways and Headland areas.

The Management Strategy Options considered within this report are focussed on management of the risks presented by radium contamination in the updrift areas of the site. As such, the Management Strategy addresses the main source of ongoing radium contamination in Ross Plantation and the subsequent anticipated decline in the radium population through implementation of the wider Management Strategy.

Ross Plantation has therefore not been directly considered within this Management Strategy although the implications of undertaking works within other areas and their subsequent positive impact on the Ross Plantation foreshore is considered.

Landward Areas

Radium contamination located within landward areas has been identified as a potential source of the ongoing radium identified on the beach, particularly as a result of washout or collapse during a storm event. However, no potentially significant risks have been identified associated with exposure to landward radium during current non-intrusive landward based activities.

Potentially significant risks have been identified as a result of future intrusive groundworks or redevelopment works. However, these risks could be managed by adopting appropriate working methods during any groundworks, including appropriate disposal of any arisings. As such, the Management Strategy does not address any potential risks from exposure to landward contamination during landward activities.

1.5 Structure of this Report

Section	Description
Section 2	This section provides an overview of the site and details a number of considerations for implementing the Management Strategy.
Section 3	This section provides an overview of the radium contamination at the site.
Section 4	This section details the assessment process to identify the Management Strategy by comparison with key attributes.
Section 5	This section documents the refining of the management strategy options for each area to form the overall Management Strategy.
Section 6	This section provides an outline specification for the identified Management Strategy. It also considers some of the practical implications of undertaking the work and associated constraints.
Section 7	This section gives and overview of the indicative programme.
Section 8	This section provides a summary overview of key risks identified for the Management Strategy.
Section 9	This section summarises the output of this report and provides recommendations.
Section 10	Reports/data/drawings used in the preparation of this report are referenced in this section.

2. Site Setting and Management Considerations

2.1 Site Setting

Landward of the Site encompasses the Sailing Club grounds, which comprises a number of buildings and structures including a two storey brick and wood building used as a clubhouse, a single storey breeze block boat and equipment store and a rescue boathouse at the high tide level. The Sailing Club grounds has a single track vehicle access from The Wynd, members' car parking, together with an area used as a boat park where boats are stored variously on trailers and dollies. The majority of the adjacent landward area is surfaced in grassed soil and broken tarmac/gravel road and car park.

Ross Plantation is located to the north west of the Sailing Club grounds and is openly accessible by the public and crossed by public footpaths including the Fife Coastal Path (FCP).

The Site, as shown on Drawing 1, comprises, in the west, a gravel beach and rock outcrops adjacent to the headland. To the east of the headland two slipways and a jetty are present within a gravel and sand beach adjacent to the Sailing Club grounds. Further north, adjacent to the boat park there is an upper sandy gravel beach with areas of sand, mud and rock outcrops extending further into the bay. The extent of the foreshore increases in width anticlockwise from the headland around Dalgety Bay. The northern part of the boat park foreshore (SEPA Area C also known as the Demarcated Area) is fenced off on the landward boundary and warning notices are posted to restrict access.

Much anthropogenic material is evident on the beach, including concrete, bricks, pottery, glassware and localised areas of cement bonded sheeting fragments. As with the particle size of the beach itself, the size of the anthropogenic material also reduces along the length of the beach from south to north.

Access is currently restricted to the southern area of the beach by a wooden fence and public advisory notices. Further north, where the beach is not fenced, it can be used by the general public for recreational activities.

The foreshore area is owned by Moray Estates with the Sailing Club grounds owned by the Dalgety bay Sailing Club.

2.1.1 Topography

Detailed ground descriptions for each of the Management Strategy areas are presented below.

Headland (Area H)

The Headland Area has a moderately sloping gravelly beach, typically extending from 0-15 m in width at Mean Low Water Neap (MLWN) and 20 m-25 m exposed at Mean Low Water Spring (MLWS). There are isolated rock outcrops. The foreshore is backed by a 4 m-5 m high steeply sloping headland protected by armour stone over most of its height. The armour stone is showing signs of deterioration and instability. The adjacent headland is a relatively flat grassed area housing the Sailing Club clubhouse. With reference to the Coastal Processes Report (AMEC, 2013a), the chainage for Area H is from 87 to 185 m, as shown on Drawing 1.

Slipways Area (Area S)
There are two concrete slipways at beach level and a raised stone jetty set within a moderately sloping gravely and sandy beach, fining towards low water. There are some rock outcrops and a low (1-2 m) high slope at the back of the beach extending up to the Sailing Club. The beach extends to between 25 m-30 m wide at Mean Low Water Neap (MLWN) with some mud and rocks beyond down to MLWS. The chainage for Area S is from 185 to 306 m.

Boat Park Bay South (Area BS)
The upper sand and gravel beach is typically 10 m-15 m wide with sand, mud and rock below. The foreshore extends to some 80 m-110 m wide at MLWN. Above the beach there is some steeply sloping rock armouring of approximately1.0-2.0 m in height with a relatively level boat park area above. The chainage for Area BS is from 306 to 384 m.

Boat Park Bay North (Area BN)
The upper sand and gravel beach is as the Boat Park Bay South but the area of sand, mud and rocks below extends some 140 m to 170 m in width down to MLWN. Above the beach there is some steeply sloping rock armouring of approximately1.0m in height with a relatively level boat park area above. Rock armouring is absent in the northern part of the area. The chainage for Area BN is from 384 to 494 m.

2.2 Coastal Processes and Radium Transport Mechanisms

The Coastal Processes Review report (AMEC 2013a) presented a review of the coastal energy data and a discussion of the sediment transport mechanisms at Dalgety Bay. These are an important consideration in the assessment of potential management strategies. A summary of the key points is provided below.

2.2.1 Wave Climate

The Coastal Processes Review report concluded that although tidal currents are a factor, waves arriving at Dalgety Bay are the primary mechanism for sediment transport on the foreshore. There are two extremes of sediment movement caused by waves on the intertidal foreshore:

- Deep-water conditions where passing waves and currents can move considerable sediment volumes in one high tide storm event; and
- Shallow water conditions where breaking/plunging waves can momentarily move substantial sediment particles within surf zone.

Design wave heights of up to 1.25 m have been calculated to potentially mobilise particles up to 8mm diameter (silts/sands/fine gravel) in deep water conditions.

2.2.2 Coastal Processes

The Headland (Area H) is most exposed to the S-SW wave fetch, with less exposure further along the coastline towards Ross Plantation. The following text summarises the key findings.

- Rock armour along the Headland offers some protection to the prevailing wave fetch, but the armour is laid to a steep wave-reflective gradient, lacks bedding stone and protective geotextile. Breaking waves may therefore potentially mobilise sediment from below the armour, with the effect being more pronounced during

storm events, which have probably already contributed to the lower beach levels in this area;

- In areas exposed to the prevailing S-SW fetch, a greater thickness of sediments could be remobilised. The potential for materials to be remobilised by wave action would be greater during storm events, and redistribution of foreshore sediments to depths approaching 0.5 m below the foreshore could be possible in exposed areas during storm conditions. Radium contamination present within foreshore sediments may therefore be redistributed along with host sediment, notably during high energy storm conditions;
- Further along the coastline in areas less exposed to the prevailing S-SW wave fetch, breaking waves may also occasionally have the potential to mobilise sediment from exposed upper foreshore and landward materials, particularly during storm events, as there is evidence of some localised erosion along the MHWS level. Slumping of the armour stone could also result in sudden exposure of landward materials which could be mobilised by breaking waves. On this basis, radium contamination present in landward sediments along the MHWS level could be released onto the foreshore within the Site.

It is possible that a combination of processes including wash out from landward materials and redistribution of sediments within the foreshore could result in radium contamination at or near the surface of the foreshore.

There are wave dominated sediment movement mechanisms still present that will transport a significant range of sediments locally north-eastwards along the coast from the Headland foreshore, and onwards through the Slipways, and Boat Park foreshore towards Ross Plantation foreshore. There is also some evidence that although relatively stable, beach levels are still adjusting to the loss of sediment supply caused by construction of the armour stone protection of the Headland, particularly around the Slipway area.

2.3 Previous and Current Work

The Dalgety Bay site has been subject to a number of surveys, both intrusive and non-intrusive, over recent years which should be read in conjunction with this report, namely:

- Enviros Intrusive Investigation (Enviros, 2007b);
- AMEC Factual Site Investigation Report (Amec, 2013a);
- AMEC Interpretative Report (AMEC, 2014b); and
- AMEC Routine Radiological Walkover Surveys (AMEC, 2013d).

2.4 Management Option Considerations and Constraints

2.4.1 Health Protection Criteria

Public Health England (PHE) has advised SEPA that the Management Strategy for Dalgety Bay should:

1. Be justified, i.e. aim to do more good than harm, in the widest sense of ‘good’ and ‘harm’;

2. Make every effort to avoid exposures above a specified level of dose, and
3. For contamination remaining that could give rise to exposures below the levels determined for the second principle, be optimised, i.e. aim to maximise the net benefit, taking wider health, social, economic and other factors into account.

To this end PHE has set out two health protection criteria in their advice to SEPA (PHE, 2014). These are:

Criterion 1

That all efforts should be made to ensure that objects that could give rise to a committed effective dose of 100mSv to an individual, regardless of object size, or an external dose of 1 Gy h^{-1}, averaged over an area of 1cm^2 skin at a depth of 70 microns, are either removed or isolated so that there is no credible current or future mechanism for exposure.

The first Criterion has been designed to ensure that every effort is made to avoid radium contamination becoming accessible in the future that could lead to serious deterministic injury or unacceptably high stochastic risks.

PHE provide activity levels corresponding to Criterion 1 based on a varying solubility. Using this information, AMEC has understood Criterion 1 to mean the removal or isolation of radium contamination with an activity equivalent to approximately 40 kBq Ra-226.

Criterion 2

Criterion 2 is the recommended lower bound criterion for the reduction of health risks to as low as reasonably achievable (ALARA). Residual health risks below Criterion 2 may be considered ALARA, whilst residual health risks above Criterion 2 but below Criterion 1 may also be ALARA but will require justification. This is the process of optimisation which forms the context for Criterion 2 which is as follows:

That radium contaminated objects remaining after application of Criterion 1 should be either removed or isolated so that the current or future probability of an individual receiving a 1 mSv committed effective dose is less than 10^{-6} per year. In addressing this criterion, optimisation should be carried out so that increasing weight is given to management options that remove or isolate objects of increasingly high activity.

AMEC has understood Criterion 2 to mean the removal or isolation of radium contamination is not required where it has an activity of less than approximately 1 kBq Ra-226. Furthermore, Criterion 2 requires removal or isolation of radium contamination, with an activity of greater than approximately 1 kBq Ra-226, where practicable to achieve, within the context of optimisation.

2.4.2 Remediation Considerations

Management Option Consideration

Excavation and screening to remove radium would be dependent on equipment detection limits and the ability to identify and segregate radium within a variety of particle sizes and may not be as effective in meeting Criterion 2 as cover systems. Cover systems would break the exposure pathway and provide a degree of shielding to remaining radium and would approach the Criterion 2 target.

Repopulation
The foreshore is a dynamic environment and radium containing material is likely to be present beyond the extent of areas which can be remediated (e.g. beyond low water or beyond the lateral extent of areas to be remediated) and which could potentially provide some degree of repopulation in the future.

'Background' Activity
The widespread presence of radium within the Dalgety Bay foreshore gives rise to an elevated 'background' which makes it difficult to distinguish individual radium containing materials below activity levels of around 3-5 kBq depending on its physical size and cover. Additionally there is some elevated background from other naturally occurring radionuclides, such as uranium in granite pebbles and as aggregate in concrete slipways etc.

2.4.3 Regulatory Considerations

There are wide ranging regulatory considerations for the management of radium contamination at Dalgety Bay. Regulations range from UK wide primary legislation (Acts), Scotland specific primary legislation (Acts), devolved secondary legislation (Scottish Statutory Instruments), Statutory Guidance and wider European directives. The various regulatory considerations with respect to any proposed management strategy for the site are summarised in Annex A.

2.4.4 Site Constraints

Site Access and Rights
The road access to the Site is via the Sailing Club entrance located at the eastern end of the The Wynd. This is a residential road. A number of houses at the eastern end of the Wynd overlook the adjacent Sailing Club grounds.

There are user rights to the foreshore area in the form of Mineral Rights. According to SEPA these are held by a housing developer.

Landward Working Area
The adjacent landward area to the Site is limited in size. Implementation of the Management Strategy is likely to require contractors' site offices and welfare facilities, areas for storage of materials, plant and equipment and stockpiling on land owned by the Sailing Club.

Foreshore Working Area
The foreshore is subject to tidal influences which can vary between spring and neap tides and meteorological conditions. The tides limit access to, and extent of work on, the foreshore. Additionally, for any Management Strategy that entails excavation, the saturated materials will require additional drainage prior to any landward processing that may be required.

On-Going Site Activities
The Sailing Club is an active facility, comprising access roads, car parking, boat park, sailing clubhouse and grounds. Minimising disruption to the sailing club activities could present a constraint during any implementation works.

Ross Plantation, the Fife Coastal Path and the Dalgety Bay foreshore are currently used for a range of recreational activities (outwith the current demarcated area) including dog walking, walking, running, cycling, bird watching and other activities. Again, minimising disruption to recreational site users may present a constraint during the implementation works.

Structures

There are several structures present at the Site and on adjacent landward areas. These include the jetty, slipways, services, sewer outfall and access roads which may all form constraints, especially where these are co-incident with the location of the radium contamination which requires management. In addition, the current rock armour coastal defences present at the site are a further constraint, particularly for techniques which require excavation or other work at or adjacent to these defences.

Ecological Constraints

Dalgety Bay is classified as a Ramsar site (a wetland of international importance), a Site of Special Scientific Interest (SSSI) and a Special Protection Area (SPA). Ecological sensitivity of the Site is assessed as high and therefore any management techniques will need to minimise any adverse effect on the local highly sensitive ecological receptors.

Sustainability

Assessment of sustainable remediation is defined as 'the practice of demonstrating, in terms of environmental, economic and social indicators, that the benefit of undertaking remediation is greater than its impact and that the optimum remediation solution is selected through the use of balanced decision making processes' by the Sustainable Remediation Forum, UK, known as SuRF-UK (CL:AIRE, 2010).

Sustainability is therefore, a further consideration, if not constraint, in the management of radium contamination at the site and development of the detailed design and programme.

Presence of Radium

The presence of radium places additional constraints on implementing the Management Strategy when considering potential exposure of such radioactive material to the workforce, site users and the wider general public, as well as the potential for contamination of equipment and plant.

Land Condition

Due to the variable nature of Made Ground, there is uncertainty about the nature, extent and composition of the ground at the site. The presence of fragments of suspected asbestos cement sheeting has been observed across the Site, commonly present at surface across the foreshore, and to a lesser degree, present in tidal flat areas.

2.4.5 Assumptions

There are a number of underlying assumptions associated with determining and implementing the Management Strategy for the Site. These assumptions will need to be tested further at design development and detailed design stage. A non-exhaustive list of the assumptions is provided below:

Design Considerations

- The key areas required for the development of a Management Strategy include the foreshore areas identified by SEPA as having potentially significant pollution linkages present due to the presence of radium (SEPA, 2013) and future scenarios that could result in contamination; and
- The existing rock armour protection to the headland and boat park areas is locally in a poor condition with evidence of slippage and wash-out of radium containing material from behind. Robust and well designed rock armouring is required to minimise any further loss of land-based radium into the foreshore environment.

Consents and Permits

- A planning application will be required to implement the main remediation works, and this will need to be accompanied by an Environmental Impact Assessment (EIA);
- Appropriate disposal routes will be available for high activity radium disposal;
- Any identified available suitably licensed waste disposal facilities for lower activity material will remain viable throughout the duration of the Management Strategy implementation;
- Removal of radium above a certain activity and replacement of foreshore materials containing lower activity material within the same area prior to deployment of a cover system achieves regulatory agreement, and
- SEPA act as the main regulatory body with a co-ordination role in facilitating the necessary permits and licences to undertake remediation works.

Land Access and Rights to Implement the Management Strategy

- The sailing club will continue to be active before, during and after implementation of the management strategy and will facilitate access to and the use of their land;
- The extent of Moray Estates landownership of the foreshore extends to the edge of the site boundary or MLWS, whichever is furthest from shore and, furthermore, Moray Estates need to agree to consent to the implementation works; and
- Any mineral rights held by other parties will not prevent the implementation of the Management Strategy.

Implementation

- Implementation will be subject to seasonal windows given the presence of over-wintering migratory birds of international importance, the limiting winter daylight hours and higher storm incidence in winter;
- Work in Areas H, S, BS and BN will have a positive effect in reducing the migration of radioactive contaminants downdrift (i.e. to the east) including the foreshore adjacent to the Ross Plantation (SEPA Area B) and
- Verification will be undertaken to the satisfaction of the regulator.

Implementation

- Effective routine monitoring and maintenance of the management measures will occur as necessary and be managed by the appropriate authorities.

2.4.6 Uncertainties

There are a number of underlying uncertainties associated with determining and implementing the Management Strategy for the Site. These include but are not limited to:

- The extent and distribution of radium within the reworked foreshore beneath the coarser particle size surface coverage is not fully defined. Further assessment/investigation will be required as part of the detailed design work;
- The volume and activity of waste materials generated during implementation is dependent on the detailed design and underlying ground conditions, for example,

the depth to rockhead is very variable and not comprehensively defined across the areas covered by the management strategy requiring further site investigation;

- The extent to which ecological receptors may have the potential to limit on-site activities, especially given the SPA, SSSI and Ramsar designation. This will require further assessment through the EIA process, and
- The ability to phase works so as to accommodate the Sailing Club and the nature of any replacement slipway or jetty access.

3. Conceptual Model Overview

3.1 Development of the Conceptual Model

The Conceptual Model for the Dalgety Bay site was developed initially by AMEC at the Preliminary Risk Assessment (Tier 1) stage and reviewed and refined during the intrusive investigation reporting (AMEC, 2014b). In general terms, the Conceptual Model represents the characteristics of the Site and indicates the possible relations between a **contaminant**, a **pathway** (or pathways) and a **receptor**.

In the context of radioactive contaminants, the Statutory Guidance[2] to support the implementation of the Radioactive Contaminated Land Regulations, defines the following:

- A radioactive contaminant is a substance which is in, on, or under the land and which has the potential to cause harm or to cause pollution of the water environment;
- A receptor is a human being which is being, or could be, harmed by a radioactive contaminant; or a water environment which is being, or could be, polluted by a radioactive contaminant, and
- A pathway is one or more routes or means by, or through, which a receptor is being exposed to, or affected by a radioactive contaminants, or could be so exposed or affected.

For a potential risk to exist at a site all three of the above elements must be present, and linked together so that a contaminant has been identified, a receptor is located on the site and there is an exposure pathway that links the contaminant to the receptor. The term **pollutant linkage** is used to describe a particular combination of contaminant-pathway-receptor relationship.

Due to the complex developmental history and dynamic processes that have resulted in the presence of radium at the site, AMEC developed the overall initial Conceptual Model for Dalgety Bay in two distinct elements as part of the Phase One Land Quality Assessment:

- A **Conceptual Site Model** representing the physical, historical or ongoing processes that have resulted in the current distribution of radium containing materials at the site, and
- A **Conceptual Exposure Model** which represents the means by which the current distribution of contaminated materials could present potential risks to the identified receptors.

The initial conceptual model for the Site is presented in full in AMEC's Phase One Land Quality Assessment Report (AMEC, 2013b).

[2] Scottish Government. Environmental Protection Act 1990: Part IIA, Contaminated Land. The Radioactive Contaminated Land (Scotland) Regulations 2007 Statutory Guidance, 28 May 2009. SG/2009/87.

3.2 AMEC Conceptual Site Model

In order to identify appropriate management strategy options, it is necessary to understand the physical, historical or ongoing processes that have resulted in the current distribution of radium materials at the site. Such processes were identified in the Initial Conceptual Site Model presented within AMEC's Phase One LQA (AMEC, 2013b).

A Conceptual Site Model was presented in the Outline Management Options report (AMEC, 2014a) which revised the Initial Conceptual Site Model following SEPA's identification of potential SPLs associated with the presence of radium within the foreshore.

The Conceptual Site Model was updated to focus only those source areas and activities which could have resulted in the presence of radium contamination on the beach. The source definition, i.e. areas where radium contamination is present on the foreshore and the processes by which pollutant linkages are plausible, as reported previously by AMEC, is summarised in Table 3.1. No potential SPLs were identified by SEPA in relation to exposure to radium in the landward areas, these have been removed from the AMEC Conceptual Site Model.

The Conceptual Site Model has been used to inform the management options within this report.

Table 3.1 AMEC Conceptual Site Model: Areas and AMEC Source Reference

Source Definition - Area and Activity	AMEC Source Reference Number[#]	Management Strategy Area Affected
East of New Harbour: Erosion or Disturbance of Material	2	H, S, BS, BN and RP
'Headland': Erosion or Disturbance of Material	5	H, S, BS, BN and RP
'Boat Park': Erosion or Disturbance of Material	8	BS. BN and RP
'Slipways and Jetty' Development: Disturbance of Material	9	S, BS, BN and RP
Ross Plantation Foreshore: Erosion and Disturbance of Material	13	RP
Dalgety Bay Beach: Deposited Material	16	All areas
Dalgety Bay Beach: Erosion or Disturbance of Material.	17	All areas

[#]: the reference number as initially defined under AMEC's Phase One LQA (AMEC, 2013b)

3.3 Pollutant Linkage Discussion

The following sub-section provides an overview of the key elements of a pollutant linkage: the contaminant distribution, the receptors and plausible pathways. These elements combine to inform appropriate management strategy options. More detailed discussion is reported in Eden Nuclear and Environment's Baseline Assessment, in preparation at the time of writing (Eden, 2014).

3.3.1 Contaminant Distribution

The AMEC 'Radiological Survey Report March 2012 to May 2013' (AMEC, 2013d), provides a summary of the results of the monthly survey and radium contamination retrieval works undertaken during the identified period. This is supplemented by AMEC's 'Factual Intrusive Investigation Report (AMEC, 2013a) and 'Dalgety Bay Stage 2 Intrusive Investigation'

(AMEC, 2014b), which presents a summary and assessment of the findings of the intrusive site investigations undertaken by AMEC between October and November 2012. The information provided below is derived from the data associated with these reports and is referenced per area.

The distribution of the radium contamination, and the strata/material types associated with these materials, are discussed below. When discussing foreshore materials, the terminology of 'Made Ground' is used to define differing types of material with anthropogenic evidence. Further details are provided in the Factual and Intrusive Investigation reports (AMEC, 2013a and 2014b).

Summary of All Depth Related Radium by Area

The number of radium items found in each assessment area for which there is a reliable measure of the depth of discovery from May 2009 to March 2014 are summarised in Table 3.2, below.

Table 3.2 Summary of Depth Related Radium Items by Assessment Area

Area	Radium Items >20kBq and <10 cm Depth	All Radium Items
Headland	3	150
Slipways	16	718
Boat Park Bay South	2	277
Boat Park Bay North	2	344

Radium items for which no depth was recorded have been excluded from the dataset. This data selection enables a comparison of the total numbers of radium items recovered with the number of items recovered which met the Dalgety Bay Particle Advisory Group (DBPAG) criteria (activity higher than 20kBq Ra-226 and shallower than 0.1 m depth).

The specification for the routine surveys have been subject to refinements through time and therefore the nature of the radium items has also changed during the survey periods (March 2012 to March 2014). In 2012, the DBPAG introduced Recovery Criteria that the monitoring survey is required to detect a 20 kBq Ra-226 item at 0.1 m depth with a 95% confidence interval. The first survey undertaken to this specification was March 2012. Since the August 2012 survey, an increased speculative targeting was introduced. Radium items of lower activity than the DBPAG monitoring and recovery criteria were also investigated and recovered.

Spatial Distribution of Radium

The following discussion describes radium recovered from AMEC's foreshore monitoring during the period March 2012 to March 2014, including additional depth information from intrusive investigation reported in the Interpretative Report (AMEC, 2014b). The distribution of radium items recovered during the work is presented on Drawing 2.

Area H

The Headland foreshore comprises Made Ground locally to approximately 1.3 m bgl. The distribution of radium items recovered from the Headland foreshore indicates lower frequency of radium items than the adjacent Slipways area. The foreshore adjacent to the southern

armoured face of the Headland did not display an obvious clustering of items towards the upper reaches of the foreshore, as observed down-drift in other assessment areas. A cluster of previously recovered items is located adjacent to the slipway at the eastern end of the Headland assessment area, similar to the adjacent Slipways area.

Items encountered on the foreshore by the survey were typically from 0-0.2 m depth, with intrusive investigation encountering radium at depths of up to 0.7 m.

Area S

Radium items are widely distributed throughout the entire Slipway area, with no clear cluster of items towards the upper foreshore, as encountered elsewhere. The intrusive investigations encountered radium in Made Ground to depths of up to 1.3 m in the Slipway Area, with the routine monitoring encountering items typically from ground level to 0.2 m depth.

Area BS

The radium items on the foreshore were recovered from Made Ground deposits at typical depths of less than 0.2 m. The items were widely distributed throughout the foreshore and were less clustered towards the upper foreshore.

Area BN

The distribution of items in Area BN is clustered towards the upper reaches of the foreshore where granular sands and gravel deposits are present at the surface. There are also a limited number of items more widely dispersed onto the lower foreshore in the wider bay area. Items are typically encountered on the foreshore at depths of 0-0.2 m bgl.

The observed activities on the foreshore are consistent with the recorded activities for items in the intrusive locations.

3.3.2 Receptor Considerations

The following discussion focuses on potential receptors across the four management strategy areas. The receptors defined by the SEPA SPLs are the '*public*'. This has been considered to include adult and child beach users, whether that be the whole beach user, such as dog walkers, or single beach (area) users, for example, those using the slipways in Area S. For each area, commentary is provided on the access and use of the foreshore.

Area H

The current rock armour defining the Headland feature is too steep to be safe to traverse (effectively a cliff), and as such is not anticipated to be used by the general public.

A mown, grassed area is present at the top of the armour stone revetment, which forms part of the recreational lawn of the Sailing Club. Although there is no restriction with respect to pedestrian access to this area for members of the public including dog walkers, recreational walkers, members of the Sailing Club and users of the Sailing Club Clubhouse are seen to frequent this area on a daily basis. This landward area does not form part of SEPAs SPLs.

The beach at the base of the armour stone revetment is within the intertidal area, and normally exposed by the tide for only limited periods (low spring tides). Furthermore, the beach comprises mainly angular and sub-angular cobbles and boulders, and is often slippery with seaweed and algal growth. The limited access by foot to this area, the difficulty in traversing it, and the absence of any particular destination for foot traffic by crossing the beach, means that relative to other areas, it is accessed much less frequently by the public.

Safe access to the base of the armour stone revetment is gained via the beach to the east of the protruding headland, to the immediate west of the Sailing Club jetty.

Typical cross sections are provided on Drawing 3 and 4 across Area H.

Area S

The slipways and jetty are in frequent use for recreational boating by members and other users of the Sailing Club. The majority of users of this area as observed during AMEC's monitoring and recovery surveys and reported in the Radiological Habits Survey Report (SEPA, 2012) have typically remained on or adjacent to the jetty and/or slipway structures. However, the potential for recreational users of the adjacent Sailing Club grounds, in particular children, to stray onto the beach area remains.

Typical cross sections are provided on Drawings 5 across Area S.

Area BS

As reported in the Habits Survey (SEPA, 2012), recreational users of the Boat Park Bay South landward area, primarily comprising dog walkers and recreational walkers, who use the gravel track which runs through the Boat Park. There is usually insufficient space between the boats stored in this area and the top of the low rock armouring to be able to walk along the extreme edge of the Boat Park, therefore the most likely exposure in this area will be to members of the Sailing Club and other persons undertaking maintenance on parked boats, or moving the boats which may be stored in this landward area. The beach is readily accessible via three main routes - by walking across the beach from the Slipways Area, by access via the beach or tidal flats within the Boat Park Bay North Area, and by descending onto the beach via a series of boulders from the current rock armouring which form an informal series of steps, approximately at the division between the Boat Park Bay North and Boat Park Bay South Areas.

Typical cross sections are provided on Drawing 6 and 7 for Area BS.

Area BN

Landward recreational users of the Boat Park Bay North area, primarily dog walkers and recreational walkers, frequently use the gravel track along with members of and visitors to the Sailing Club.

The beach is readily accessible via three main routes - by walking across the beach and tidal flats from the adjacent Boat Park Bay South Area, by access via the beach from the coast adjacent to Ross Plantation, and by descending directly onto the beach via a series of boulders from the rock armouring which form an informal series of steps, approximately at the division between the Boat Park Bay North and Boat Park Bay South Areas.

Demarcation signage has been installed to identify that the beach poses a risk to human health from radium contamination, and advises against access. However, members of the public have observed accessing the beach in this area.

Typical cross sections are provided on Drawing 7, 8 and 9 for Area BN (including Sub-Area BN-Z).

3.3.3 Pathway Considerations

The key pathways relate to intrusive and non-intrusive activities on the foreshore whereby receptors (beach users) can come into inadvertent contact with radium via dermal contact, ingestion, irradiation or inhalation.

More detailed discussion of the conceptual site model and exposure model is provided in the interpretative report (AMEC, 2014b) and further detailed quantitative risk assessment is provided in the revised baseline report (Eden, 2014).

4. Management Strategy Optioneering

4.1 High Level Options Appraisal

4.1.1 Outline Management Options Appraisal

A series of screening stages was completed during the Outline Management Options Appraisal (AMEC, 2014a). This identified four broad management techniques to be assessed further and concluded that a combination would provide optimum benefit:

- Exclusion of receptors;
- Cover system/encapsulation;
- Excavation and disposal; and
- An optimised approach comprising a number of remedial techniques.

These options were assessed against a number of generic criteria derived from the Model Procedures for the Management of land Contamination, CLR 11 (EA, 2004) developed with SEPA and others and published by the Environment Agency, and high level consideration of the SuRF (UK) Framework (CL:AIRE, 2010).

4.2 Developing the Management Strategy

To progress from outline management options to the Management Strategy a staged process has been undertaken.

This has been completed in general accordance with recognised good practice guidance provided in the SAFEGROUNDS publication 'Guide to the Comparison of Contaminated Land Management Options' (CIRIA, 2009) and a high level consideration of SuRF (UK). This good practice maps and expands on the options appraisal stage presented in CRL11. For the purposes of developing the Management Strategy for Dalgety Bay, this involved:

- Stage 1: Defining possible management strategy options that broadly fall into the categories identified in the Outline Management Options Appraisal;
- Stage 2: Undertake Tier 1 screening of the possible management strategy options against: construction viability attributes (e.g. practicality, durability etc.) and removing those that are not satisfactory;
- Stage 3: Undertake Tier 2 screening of the remaining management strategy options against: environmental and social attributes (stakeholder and environmental considerations) and removing those that are not satisfactory;
- Stage 4: Tier 3 screening of the remaining management strategy options against capital and maintenance cost and maintenance considerations to derive a short-list of the Management Strategy options for each area;
- Stage 5: Defining the optimum Management Strategy by consideration of the overarching sustainability as described in Section 6.

The following sections describe and define each stage of this process.

4.3 Stage 1: Defining Options

4.3.1 Introduction

The four options identified in Section 4.1.1 above, were reviewed against the health protection criteria presented in Section 2.4.1. The option of excluding receptors through use of control measures, i.e. fencing and warning notices, are valid management measures consistent with current best practice, but may not be sustainable for the longer term given the requirement to:

- Isolate or remove objects that could give a committed effective dose of 100 mSv to an individual (Criterion 1);
- That the future probability of an individual receiving 1 mSv committed effective dose is to be less than 10^{-6} per year (Criterion 2), and
- Given the findings of the detailed quantitative risk assessment.

For this reason, the remaining three options identified in Section 4.1.1 were considered further.

For each of the four main areas previously identified requiring effective long term management (Area H through to Area BN) and the sub-area (BN-Z), management strategy options have been defined and describe, as detailed below. Each option is provided with a unique identifier, a summary heading and a more detailed description. Single options and logical combinations are provided.

With each option, the potential significant pollutant linkage being addressed is also identified. For example, the excavation and removal of radium in Area H would have the indirect consequence of removing contamination that could otherwise potentially repopulate the downdrift Area S. The numbers provided under the column 'Addressing AMEC Pollutant Linkage' refer to the numerical identifier provided in Table 3.1.

4.3.2 Area H

Area H comprises the westernmost area between the harbour wall and the slipways, dominated by the armour stone protected headland. It includes SEPA Area F and the south western third of Area E up to the jetty.

A number of potential options have been defined in Table 4.1. These comprise six single options with the prefix H for Headland, referenced sequentially H1 through to H6. There are 11 combinations of single options that are referenced sequentially H7A to H7K.

Table 4.1 Area H Management Strategy Option Descriptions

Option ID	Option Summary and Description	Addressing AMEC Source Identities*
Single Strategies (H1 to H6)		
H1	***Excavate, screen, replace foreshore*** This option requires the excavation of the foreshore from the base of the current armour stone to the mean low water spring. Typically the depth of excavation would be 1.5 times the anticipated storm reworking depth, i.e. to 0.8 m bgl which equates to the average thickness of reworked foreshore materials with anthropogenic materials. Excavated materials would be processed at a landward location to remove radioactive contamination. The foreshore material, less identifiable contamination, would be replaced and the screened radium contamination removed off-site. This option is subject to regulatory agreement for the replacement of the screened foreshore materials.	2 and 5 (partial),8,9, 13, 17
H2	***Excavate to containment cell, import clean*** This option is similar to H1 for the purpose of excavation. However, the foreshore materials would not require screening and instead would be placed within an engineered containment cell located on site. Clean imported materials would be required to infill the resultant lowering of the foreshore from excavation activities.	2 and 5 (partial),8,9, 13, 17
H3	***Excavate, screen, off-site disposal, import clean*** This option is also similar to H1 and H2 in excavation of the foreshore but all materials would be removed off-site for disposal. Pre-screening would be required to ensure radium contamination of a certain activity are removed thus allow the bulk of foreshore to be disposed to landfill. Clean imported materials would be required to infill the resultant lowering of the foreshore from excavation activities.	2 and 5 (partial),8,9, 13, 17
H4	***Reinforcement/replacement of current armour stone, extend over foreshore*** The current armour stone that forms a revetment up to 5 m high would be reinforced or replaced. There is little evidence of filter stone layer or geotextile layering in the current armouring. For this option, the armouring would continue across the foreshore to the mean low water spring to ensure the exposed foreshore, where there have been radium finds, is covered. Detectable radium contamination, certainly >40 kBq, in the foreshore and headland embankment encountered during construction would be removed. However, the foreshore in Area H is not proposed to be turned to remove all >40 kBq radium prior to extending rock armouring over the foreshore (as is the case in the other areas) due to a number of considerations including the narrow window of opportunity to undertake the works due to tides, the higher energy coastal process environment, the variable ground conditions (rock-head) and the comparatively low use of this area by beach users.	2 and 5 (partial),8,9, 13 and 17
H5	***Structurally reinforce current armour stone*** This option is similar to H4 but does not extend over the foreshore.	2 and 5
H6	***Marine barrier construction*** This option, whether groyne or off-shore solution, would be designed to reduce the impact from waves onto the foreshore. Depending on design, there could be the added benefit of encouraging natural processes of beach accretion across all four areas, thus permanently burying contaminated materials, with all the amenity benefits that the increased beach area would bring.	2, 5,8,9,13, 16 and 17 (partial)

Table 4.1 (continued) Area H Management Strategy Option Descriptions

Option ID	Option Summary and Description	Addressing AMEC Source Identities *
Combined Strategies (H7 series)		
H7A	***Excavate, screen, replace foreshore and reinforce armour stone*** This is a combination of H1 and H5.	2, 5,8,9,13
H7B	***Excavate, screen, replace foreshore and construct marine barrier*** This is a combination of H1 and H6.	2 and 5 (partial),8,9, 13, 16 and 17
H7C	***Excavate to containment cell, import clean and reinforce armour stone*** This is a combination of H2 and H5.	2, 5,8,9 and 13
H7D	***Excavate to containment cell, import clean and construct marine barrier*** This is a combination of H2 and H6.	2 and 5 (partial),8,9, 13, 16 and 17
H7E	***Excavate, screen, off-site disposal, import clean and reinforce armour stone*** This is a combination of H3 and H5.	2, 5,8,9 and 13
H7F	***Excavate, screen, off-site disposal, import clean and construct marine barrier*** This is a combination of H3 and H6.	2 and 5 (partial),8,9, and 13
H7G	***Reinforce/replace current armour stone, extend over foreshore and construct marine barrier*** This is a combination of H4 and H6.	2, 5,8,9,13, 16 and 17
H7H	***Reinforce current armour stone and construct marine barrier*** This is a combination of H5 and H6.	2, 5,8,9 and13
H7I	***Excavate, screen, replace foreshore, reinforce armour stone and construct marine barrier*** This is a combination of H1, H5 and H6.	2,5,8,9,13, 16 and 17
H7J	***Excavate to containment cell, import clean, reinforce armour stone and construct marine barrier*** This is a combination of H2, H5 and H6.	2, 5,8,9, 13, 16 and 17
H7K	***Excavate, screen, off-site disposal, import clean and reinforce armour stone and construct marine barrier*** This is a combination of H3, H5 and H6.	2, 5,8,9,13, 16 and 17

*Direct impact/indirect impact with reference to source area and activity in Table 3.1.

4.3.3 Area S

Area S comprises the central beach area backed by low natural rock outcrops and the sailing club area. It is dominated by the jetty, two slipways and natural rock outcrops to the east.

A number of potential options have been defined in Table 4.2. These comprise six single options with the prefix S for Slipways, referenced sequentially S1 through to S6. There are two combinations of single options that are referenced sequentially S7A and S7B.

Table 4.2 Area S Management Strategy Option Descriptions

Option ID	Option Summary and Description	Addressing AMEC Source Identities
Single Strategies (S1 to S6)		
S1	***Excavate, screen, replace foreshore*** This option requires the excavation of the foreshore from the base of the rock outcrop to the mean low water spring. Typically the depth of excavation would be 1.5 times the anticipated storm reworking depth, i.e. to 0.8m bgl which equates to the average thickness of reworked foreshore materials with anthropogenic materials. Excavated materials would be processed at a landward location to remove radium. The foreshore material, less identifiable radium, would be replaced whilst the screened radium would be removed off-site. This option may also require the breaking out of current slipways and jetty to access potential underlying radium and later reconstruction. This option is subject to regulatory agreement for the replacement of the screened foreshore materials.	8 (partial),9 and 13
S2	***Excavate to containment cell, import clean*** This option is similar to H1 for the purpose of excavation including the slipways and jetty. However, the foreshore materials would not require screening and instead would be placed within an engineered containment cell located on site. Clean imported materials would be required to infill the resultant lowering of the foreshore from excavation activities. Slipways and jetty (if removed) would be reconstructed.	8,9 and 13
S3	***Excavate, screen, off-site disposal, import clean*** This option is also similar to H1 and H2 in excavation of the foreshore and potential removal of slipways and jetty but all materials would be removed off-site for disposal. Pre-screening would be required to ensure radium of a certain activity is removed thus allow the bulk of foreshore/jetty to be disposed to landfill. Clean imported materials would be required to infill the resultant lowering of the foreshore from excavation activities and the slipways/jetty reconstructed.	8,9 and 13
S4	***Removal of radium to meet Criterion 1, concrete over foreshore*** This option requires the 'in-situ' removal of radium >40 kBq to meet Criterion 1 followed by the encapsulation of the foreshore to the mean low water spring or site boundary (whichever is closest to land). Engineered concrete would extend from the current rock outcrop, across slipways and jetty and at its terminus, extend vertically onto the underlying bedrock. This option is dependent upon regulatory agreement for replacing foreshore materials post removal of radium >40 kBq.	8,9 and 13
S5	***Removal of radium to meet Criterion 1, build replacement slipway and cover foreshore (armour)*** This option requires the 'in-situ' removal of radium >40 kBq to meet Criterion 1 followed by the removal of the current slipways and jetty where radium may be present beneath, construction of a replacement slipway and the covering of the remainder of the foreshore with armour stone to the mean low water spring or site boundary (whichever is closest to land). Detectable radium, certainly >40 kBq, in the foreshore encountered during construction would be removed. This option is dependent upon regulatory agreement for replacing foreshore materials post removal of radium >40 kBq.	8,9 and 13

Table 4.2 (continued) Area S Management Strategy Option Descriptions

Option ID	Option Summary and Description	Addressing AMEC Source Identities
S6	***Marine barrier construction*** This option, whether groyne or off-shore solution, would be designed to reduce the impact from waves onto the foreshore. Depending on design, there could be the added benefit of encouraging natural processes of beach accretion. This option should be viewed together with Option H6.	8,9,13, 16 and 17
Combination of Strategies (S7 series)		
S7A	***Removal of radium to meet Criterion 1, concrete over foreshore and construct marine barrier*** This is a combination of S4 and S6.	8,9,13, 16 and 17
S7B	***Removal of radium to meet Criterion 1, build replacement slipway, cover foreshore (armour) and construct marine barrier*** This is a combination of S5 and S6.	8,9,13, 16 and 17

*Direct impact/indirect impact with reference to source area and activity in Table 3.1.

4.3.4 Area BS

Area BS is adjacent to the southern part of the boat park, which is protected by armour stone. The wide foreshore comprises varying beach materials interrupted by substantial rock outcrops.

A number of potential options have been defined in Table 4.3 for Area BS. These comprise six single options with the prefix BS for Boat Park Bay South, referenced sequentially BS1 through to BS6. There are seven combinations of single options that are referenced sequentially BS7A to BS7G.

Table 4.3 Area BS Management Strategy Option Descriptions

Option ID	Option Summary and Description	Addressing AMEC Source Identities
Single Strategies (BS1 to BS6)		
BS1	***Monitor and remove radium contamination*** This option comprises the continued monitoring of the foreshore and the removal of radioactive contamination. This option is based on the assumption that the population of radium contamination will continue to decrease as up-drift radium contamination are isolated.	8, 13 (partial)
BS2	***Excavate upper sandy foreshore (strand), screen and replace foreshore*** This option requires the excavation of the foreshore from the base of the rock armour to the edge of the strand where the highest density of radioactive items have been located. Typically the depth of excavation would be 1.5 times the anticipated storm reworking depth, i.e. to 0.5 m bgl which equates to the average thickness of reworked foreshore materials with anthropogenic materials. Excavated materials would be processed at a landward location to remove radioactive contamination. The foreshore material, less identifiable contamination, would be replaced and the screened radium contamination removed off-site. This option is subject to regulatory agreement for the replacement of the screened foreshore materials.	8 and 13 (partial
BS3	***Excavate upper sandy foreshore (strand) to containment cell, import clean*** As for BS2 but excavated materials would not require screening and would instead be placed directly into an engineered containment cell located landward. Clean imported materials would be required to infill the resultant lowering of the foreshore from excavation activities.	8 and 13
BS4	***Excavate upper sandy foreshore (strand) for off-site disposal, import clean*** As for BS2 but with all screened materials removed off-site for disposal. Clean imported materials would be required to infill the resultant lowering of the foreshore from excavation activities.	8 and 13
BS5	***Reinforce/replace current rock armouring*** This option would involve the improvement of the current rock armouring. The current construction comprises a double layer of approximately 1 m rock armour boulders on damaged filter cloth with an absence of filter stone, bedding or toe detail. Ad-hoc filling and repairs have been completed. Detectable radium contamination, certainly >40 kBq, in the foreshore encountered during construction would be removed.	8 (partial)
BS6	***Removal of radium to meet Criterion 1, reinforce/replace and extend current rock armour to cover the upper sandy foreshore*** As for BS5, but with the removal of radium >40kBq from the upper sandy foreshore (strand) as a precursor to extending the rock armouring over strand. This option is dependent upon the regulators approving the replacement of foreshore materials once the Criterion 1 radium has been removed.	8 and 13

Table 4.3 (continued) Area BS Management Strategy Option Descriptions

Option ID	Option Summary and Description	Addressing AMEC Source Identities
Combination of Stratergies (BS7 series)		
BS7A	***Excavation of strand, screen, replace and on-going monitoring*** This is a combination of BS2 and BS1.	8 (partial) and 13
BS7B	***Excavation of strand to containment cell, import clean and on-going monitoring*** This is a combination of BS3 and BS1.	8 and 13
BS7C	***Excavation of strand, screen, off-site disposal, import clean and on-going monitoring*** This is a combination of BS4 and BS1.	8 and 13
BS7D	***Excavation of strand, screen, replace and reinforce/replace current rock armouring*** This is a combination of BS2 and BS5.	8 (partial) and 13
BS7E	***Excavation of strand to containment cell, import clean and reinforce/replace current rock armouring*** This is a combination of BS3 and BS5.	8 and 13
BS7F	***Excavation of strand, screen, off-site disposal, import clean and reinforce/replace current rock armouring*** This is a combination of BS4 and BS5.	8 and 13
BS7G	***Reinforce/replace current rock armouring and on-going monitoring*** This is a combination of BS5 and BS1.	8 and 13

*Direct impact/indirect impact with reference to source area and activity in Table 3.1.

4.3.5 Area BN

Area BN is adjacent to the north end of the boat park, which is protected by rock armour (with the exception of the northernmost section of the area as described under Sub-Area BN-Z). The very wide foreshore comprises varying beach materials interrupted by substantial rock outcrops.

The management options for Area BN are essentially the same as Area BS given the similarity in environmental context. The options are referenced BN1 to BN6 for single options and include a BN7 series which mirrors the BS7 combination of options. One of the main physical differences between the two areas relates to discontinuous rock armouring in the north of the area where there is evidence of localised wave erosion. A separate set of options has been considered for this sub-area (referenced Sub-Area BN-Z) as described below.

Sub-Area BN-Z

Sub-Area BN-Z is the unprotected part of Area BN north of the reclaimed boat park, which is eroding along the MHWS line due to the "end effect" of the sudden lack of armour stone. The foreshore comprises varying beach materials interrupted by substantial rock outcrops.

There are four single options references sequentially BNZ1 through to BNZ4 and two combination of single options referenced BNZ5A and BNZ5B.

Table 4.4 Area BNZ Management Strategy Option Descriptions

Option ID	Option Summary and Description	Addressing AMEC Source Identities
Single Option (BNZ1 to BNZ4)		
BNZ1	***Monitor and remove radium contamination on foreshore*** This option comprises the continued monitoring of the foreshore and the removal of radioactive contamination. This option is based on the assumption that wave erosion may possible lead to further repopulation of radium contamination from the landward ashy infill.	8 (partial) and 13
BNZ2	***Excavate localised landward ashy infill to on-site containment area, replace with clean import*** This involves the full depth excavation of landward ashy infill immediately adjacent to the foreshore to an approximate 5 m lateral extent with direct placement into an engineered containment cell. Clean import material would replace that excavated.	8 (partial) and 13
BNZ3	***Excavate localised ashy infill for off-site disposal, replace with clean import*** As for BNZ2 but the ashy infill would require screening prior to disposal. The resultant void would require backfilling with clean import.	8 (partial) and 13
BNZ4	***Install rock armour*** This option would isolate the landward ashy infill by installing an engineered rock armouring system along the remainder of the northern foreshore within Area BN. The lateral extent of rock armouring would be designed to gradually taper to ensure the processes of erosion at work in Area BNZ are not transferred down-drift.	8 (partial)
Combination of Strategies (BNZ5 series)		
BNZ5A	***Excavate localised landward ashy infill to on-site containment area, replace with clean import and install rock armour*** This is a combination of BNZ2 and BNZ4.	8 and13
BNZ5B	***Excavate localised ashy infill for off-site disposal, replace with clean import and install rock armour*** This is a combination of BNZ3 and BNZ4.	8 and 13

*Direct impact/indirect impact with reference to source area and activity in Table 3.1.

4.4 Stage 2: Construction Viability Attribute Screening

4.4.1 Introduction

The tables presented in Annex B provide a scored appraisal of the construction viability attributes considered necessary for the practical implementation of either a single management option (Attribute Table 1A) or combination of options (Attribute Table 1B). This step does not consider any of the regulatory, environmental or financial implications so as to ensure an option is considered purely on its technical and practical merits.

4.4.2 Tier 1 Attribute Definition

There are five attributes that have been considered at the Tier 1 stage of screening. These are defined below in Table 4.5.

Table 4.5 Tier 1 Attribute Definition

Attribute	Definition
Practicality	The relative ease and ability of a competent and experienced contractor to implement the proposed option within the physical constraints of the specific area of the site and local working environment.
Effectiveness for Area	The effectiveness of one option, or combination, to mitigating the area specific potential pollutant linkages identified.
Durability	The relative longevity and maintainability (relative ease) of either one option, or a combination (particularly important given the coastal environment context of the site). This is in relation to the requirement for a minimum 25 year longevity.
Construction Certainty	The relative confidence that the proposed option or combinations can be readily constructed with suitable and sufficient materials and equipment and with relative certainty of quantities within a defined programme of works.
Coastal Processes Impact	The degree of variation or impact to any coastal processes, either positive (i.e. encouraging accretion of sediment/rising beach levels) or negative (i.e. encouraging erosion of sediment/ falling beach levels) that are currently (pre-remediation) in operation, caused directly by the completed (post-implementation) works.

4.4.3 Attribute Scoring

For every option, a score has been assessed ranging from the lowest score 1, which represents a worst case scenario, though to the highest score of 5, which represents the best case scenario.

For example, with respect to the first attribute of ‘practicality’, one of the options may require the excavation of the foreshore. The scenario could be that the foreshore is very difficult to access and remains below the tide level except for spring lows. If this were simply too impractical so as to be very difficult and near impossible, this would score a worst case scenario of 1. On the other hand, if foreshore excavation was possible though difficult, this would score a 2.

At the other end of the scale, if the foreshore was outside of the tidal level except for extreme spring highs, excavation may be far more practical and score a 4. If the work is straight forward for a competent and experienced contractor without the constraints for tides, this work activity would score a 5.

The following Table 4.6 summarises the scoring option for the Tier 1 attributes.

Table 4.6 Tier 1 Attribute Scoring Strategy Definition

Attribute	Score				
	1	2	3	4	5
Practicality	Very difficult to implement	Difficult to implement	Achievable with effort	Achievable	Straightforward
Effectiveness for Area	Does not address PLs within area	Partly effective in mitigating PLs within area	Moderately effective in mitigating PLs within area	Majority of PLs within area are mitigated	Wholly effective in mitigating PLs within area
Durability	Not durable	Partially durable	Moderately durable	Durable	Very durable
Construction Certainty	Very low confidence	Low confidence	Moderate confidence	High confidence	Very high confidence
Coastal Processes Impact	High negative impact to current coastal processes	Slight negative impact to current coastal processes	No impact to current coastal processes	Slight positive impact to current coastal processes	High positive impact to current coastal processes

The detailed justification for the scoring provided in Attribute Tables 1A and 1B is provided in Annex B.

4.4.4 Output From Stage 2

The relative scoring from the Tier 1 attributes screening assessment for single and combination of options per area are presented in Attribute Table 1A and Table 1B (in Annex B). In defining what should be considered at the next stage a process of elimination has been undertaken. The rationale for elimination is twofold:

1. A option (or combination) that cannot work in isolation cannot justifiably be taken forward for further assessment (non-compliance to effectiveness objective); and

2. A option (or combination) that has comparatively low scores per area are unlikely to be the most pragmatic options going forward given the Stage 2 screening bias is to overall constructability.

A summary of the management options carried through to the next stage are summarised below in Table 4.7.

Table 4.7 Management Strategies Carried Through to Stage 3

Area	Option ID	Option Summary Description
Area H (Headland)	H7I	Excavation of foreshore, remove radium contamination, replace, reinforce current armouring stone and marine barrier installation.
	H7J	Excavation of foreshore to site containment area, import clean material, reinforce current armouring stone and marine barrier installation.
	H7K	Excavation of foreshore for off-site disposal, import clean material, reinforce current armouring stone and marine barrier installation.
	H4	Reinforce armour stone and extend rock armour over all of the foreshore.
	H7A	Excavation of foreshore, remove radium contamination, replace and reinforce current armouring stone.
	H7E	Excavation of foreshore for off-site disposal, import clean material and reinforce current armouring stone.
	H7G	Reinforce armour stone and extend rock armour over foreshore and installation of marine barrier.
	H7C	Excavation of foreshore to site containment area, import clean material and reinforce current armouring stone.
Area S (Slipways)	S1	Excavate foreshore, remove radium contamination and replace.
	S3	Excavate foreshore dispose off-site and replace foreshore with clean import.
	S5	Remove radium to meet Criterion 1, build replacement slipway and cover or rock armour the foreshore.
	S2	Excavate foreshore and remove to site containment area and replace foreshore with clean import.
	S7A	Remove radium to meet Criterion 1, cover foreshore with concrete (large slipway) and construct marine barrier.
	S7B	Remove radium to meet Criterion 1, build replacement slipway and cover or rock armour foreshore and construct marine barrier.
	S4	Remove radium to meet Criterion 1,cover foreshore with concrete (large slipway).
Area BS/BN (Boat Park Bay South/ Boat Park Bay North)	BS6/BN6	Remove radium to meet Criterion 1, improve and extend current rock armour to cover the sandy foreshore (strand).
	BS7G/ BN7G	Reinforce/replace current rock armouring and undertake on-going monitoring.
	BS1/BN1	Monitor and remove radium contamination.
	BS7D/ BN7D	Excavation of strand, screen, replace and reinforce/replace current rock armouring.
	BS7E/ BN7E	Excavation of strand to site containment area, import clean material and reinforce/replace current rock armouring.
	BS7F/ BN7F	Excavation of strand for off-site disposal, import clean material and reinforce/replace current rock armouring.

Table 4.7 (continued) Management Strategies Carried Through to Stage 3

Area	Option ID	Option Summary Description
Sub-Area BN-Z (Boat Park Bay North – Zone 1)	BNZ4	Install rock armour.
	BNZ5A	Excavate landward ashy infill to site containment area and install rock armour.
	BNZ5B	Excavate landward ashy infill for off-site disposal and install rock armour.
	BNZ3	Excavate landward ashy infill for off-site disposal.
	BNZ1	Monitor and remove radium contamination.

The largest number of options carried forward (eight in total) was for Area H where scoring between viable options was relatively close. This equates to all options being carried forward that can work in isolation, i.e. elimination by non-compliance.

The same process applied to Area S which carried forward seven options for further assessment. Again, elimination was due to non-compliance.

Six options were carried forward for Area BS and Area BN. Elimination was due to either non-compliance or, as in the case of three options (BS7A-BS7C/BN7A-BN7C) due to comparative low scoring.

Finally, within Sub-Area BN-Z five options were carried forward with only one eliminated due to low scoring (BNZ2). The options carried forward for screening at Stage 3 are provided in Attribute Table 2, provided in Annex C.

4.5 Stage 3: Tier 2 Attribute Screening

4.5.1 Introduction

Attribute Table 2, provided in Annex D, assesses the attributes associated with environmental and social considerations. The viable top scoring option or options from the 'Tier 1 Attribute Screening' have been carried through from Attribute Tables 1A and 1B for further assessment. Where there is a group of options that score closely, the whole group has been taken through for further consideration. The lowest scoring options have not been considered further as these are deemed to have not satisfactorily passed the 'Tier 1 Attribute' screen.

4.5.2 Attribute Definition

There are five attributes that have been considered at the second stage of screening. These are defined below in Table 4.8.

Table 4.8 Environmental and Social Attribute Definition

Attribute	Definition
Works Impact	The likely impact to amenity receptors as a direct result of employing a single option or combination. Amenity receptors include local residents and users of the landward area of the site (walking, sailing, bird watching etc.)
Environmental Effects	The likely impact to biodiversity as a direct result of employing a option or combination. Dalgety Bay is designated as part of a wider Ramsar site (and also qualifies as a SSSI and SPA) and under its designation is particularly noted for assemblages of birds of international importance. Adjacent to BN and BS are areas of mudflats.
Processes and Authorisations	The relative complexity of implementing a option, or combination, with respect to required processes and authorisations, for example, approval from a number of regulatory bodies with overlapping responsibilities may be required.
Stakeholder Support	The relative degree of scheme acceptance from stakeholders including local residents and local site users (landward and foreshore), land owners and other non-regulatory bodies.
Sustainability	The relative environmental, social and economic benefit (or otherwise) of undertaking a single option, or combination.

4.5.3 Attribute Scoring

As for Attribute Tables 1A and 1B, for every management strategy option, a score has been provided ranging from the lowest score 1, which represents a worst case scenario, though to the highest score of 5, which represents the best case scenario.

The following Table 4.9 summarises the scoring strategy for the Tier 2 attributes.

Table 4.9 Tier 2 Attribute Scoring Strategy Definition

Attribute	Score				
	1	2	3	4	5
Works Impact	Very high impact to amenity receptors	High impact to amenity receptors	Moderate impact to amenity receptors	Low impact to amenity receptors	Very low impact to amenity receptors
Environmental Effects	Very high impact to biodiversity	High impact to biodiversity	Moderate impact to biodiversity	Low impact to biodiversity	Very low impact to biodiversity
Processes and Authorisations	Numerous authorisations that are very difficult to achieve simultaneously	Numerous authorisations that are difficult to achieved simultaneously	Numerous authorisations that can be achieved simultaneously	Small number of authorisations that can be achieved simultaneously	Very small (few) number of authorisations that can be achieved simultaneously
Stakeholder Support	Unacceptable to the majority of stakeholders	Unlikely to be acceptable to the majority of stakeholders	Likely to be acceptable to the majority of stakeholders	Highly likely to be acceptable to the majority of stakeholders	Certain to be acceptable to the majority of stakeholders
Sustainability	Not sustainable	Low degree of sustainability	Moderate degree of sustainability	High degree of sustainability	Very high degree sustainability

The text provided in Annex C provides an explanation as to the scoring for each option being considered. The ordering of the options discussed relates to their relative ranking from Stage 2, highest scoring first. The explanations should be read in conjunction with Attribute Table 2 included in Annex C.

4.5.4 Output from Stage 3

The individual scores from screening against the Tier 2 attributes, as presented in Attribute Table 2, were summated with the scores of viable options from Attribute Tables 1A and 1B. The combined scores were then ranked to identify viable options that were both pragmatic and could be satisfactorily implemented.

The top scoring (combined scores) options were taken through. These were defined by either:

1. There being a distinct difference between higher and lower scoring options; or
2. Where a number of options were available, the three highest scoring options being carried forward for cost assessment.

The output is summarised below in Table 4.10.

Table 4.10 Management Strategies Carried Through to Stage 4

Area	Option ID	Option Summary Descriptions
Area H (Headland)	H4	Reinforce armour stone and extend rock armour over all of the foreshore.
	H7G	Reinforce armour stone and extend rock armour over foreshore and installation of marine barrier.
Area S (slipways)	S5	Remove radium to meet Criterion 1, build replacement slipway and cover or rock armour the foreshore.
	S7B	Remove radium to meet Criterion 1, build replacement slipway and cover or rock armour foreshore and construct marine barrier.
	S3	Excavate foreshore dispose off-site and replace foreshore with clean import.
Area BS/BN (Boat Park Bay South/ Boat Park Bay North)	BS1/BN1	Monitor and remove radioactive material.
	BS7G/ BN7G	Reinforce/replace current rock armouring and undertake on-going monitoring.
	BS6/BN6	Remove radium to meet Criterion 1, improve and extend current rock armour to cover the sandy foreshore (strand).
Sub-Area BN-Z (Boat Park Bay North – Zone 1)	BNZ4	Install rock armour.
	BNZ1	Monitor and remove radioactive material.
	BNZ5B	Excavate landward ashy infill for off-site disposal and install rock armour.

4.6 Stage 4: Economic Viability

4.6.1 Introduction

The final stage of screening involves the consideration of likely cost. This comprises two elements:

- The capital cost (i.e. the construction cost for engineering solutions); and
- The maintenance cost.

For example, an option may have a very high capital cost because it is a complex and time consuming activity, but results in very low or no maintenance costs. In contrast, another option may have a reasonably low capital cost because it is relatively straightforward and readily achievable, but requires on-going maintenance over a long period of time. This final screening by comparison of costs is concerned with understanding what is termed the 'whole-life' costs for each of the highest ranking options.

4.6.2 Cost Attribute Definition

Capital costs are defined as the upfront costs required to implement an option. These costs assume all necessary licences, permits and authorisations have been accounted for and the detailed design has been completed and agreed with the necessary parties. The capital cost would include for site set-up and on-going maintenance of contractors offices and stores, plant and equipment and their maintenance, personnel, materials, protective equipment, surveys, verification and reporting. In summary, this is the cost of implementing the option.

Maintenance costs are defined as any costs required following on from the implementation of an option that are necessary to ensure its continued effectiveness. For example, where imported cover material is used across a foreshore area to encapsulate radium, this will require maintenance to ensure coastal processes, including storm events, are not degrading the integrity of the cover. In summary, this is the cost to maintain the effectiveness of an option.

4.6.3 Attribute Scoring

Capital Cost Attribute Scoring

Following the assessment in Attribute Tables 1A, 1B and 2, the highest ranking management options have been assessed to factor in the capital costs to aid in the assessment of cost benefit. A scoring system has been developed based on the actual calculated costs and costs relative to other viable options *per area*. This system has enabled a ranking and scoring. A score has been allocated to each option ranging from the lowest score 1, which represents the highest cost option, though to the highest score of 5, which represents the scenario requiring the lowest capital investment.

The following Table 4.11 summarises the scoring option for the capital cost assessment:

Table 4.11 Capital Cost Attribute Scoring Strategy Definition

Attribute	Score				
	1	2	3	4	5
Capital requirement	A strategy requiring a very high degree of capital investment	A strategy requiring relatively high capital investment	A strategy requiring a moderate degree of capital investment	A strategy requiring relatively low capital investment	A strategy requiring low capital investment

Maintenance Cost Attribute Definition

Maintenance costs have been calculated for each of the selected options following the previous capital cost assessment. Within each of the areas the maintenance costs have then been scored relatively against each other on a scale of 1 to 5 with 1 representing a higher ongoing maintenance cost requirement and 5 requiring a lower maintenance cost commitment.

The following Table 4.12 summarises the scoring strategy for the maintenance cost assessment:

Table 4.12 Maintenance Scoring Strategy Definition

Attribute	Score				
	1	2	3	4	5
Maintenance	A strategy requiring a complex, high impact or high cost maintenance commitment	A strategy requiring relatively complex, with some impact or high cost maintenance commitment	A strategy requiring moderate maintenance commitment	A strategy with little impact, lower cost or more simple maintenance commitment	A strategy requiring minimal or very simple, maintenance commitment

The cost scoring for the management options brought forward for Stage 4 assessment are provided in Attribute Table 3, provided in Annex D.

4.6.4 Stage 4 Screening

Area H

The highest ranking options for Area H are:

- H4 – Reinforce armour stone and extend rock armour over all of the foreshore, and
- H7G – Reinforce armour stone and extend rock armour over all of the foreshore and installation of a marine barrier.

Capital Costs

The additional capital costs associated with installing a marine barrier has no additional net benefit to achieving the required health protection criteria i.e. H4 as is shown in Attribute Table 3.

Maintenance Costs

Both options require a degree of maintenance, but relative to one another, H7G is anticipated to require less given the protection afforded by the marine barrier. Typically, well engineered marine barriers can have low maintenance requirements, especially given the site environmental setting.

Area S

The highest ranking options for Area S are:

- S5 – Remove radium in line with Criterion 1, build replacement slipway and rock armour the foreshore;
- S7B – Remove radium in line with Criterion 1, build replacement slipway, rock armour the foreshore and construct a marine barrier, and
- S3 – Excavate foreshore, remove of-site and replace with clean import.

Capital Costs

Capital costs are higher with the greatest upfront cost attributed to S3, as is shown in Attribute Table 3 (Annex D). This cost is due in part to the complex and programme intensive excavation of the foreshore all being undertaken in a controlled manner. The temporary works associated with such an approach could, in and of themselves, equate to significant proportion of costs for other options. In comparison, rock armouring across the foreshore is a comparatively simpler approach and much quicker to achieve. Marine barriers are likewise comparatively lower in cost due to standard approaches to construction.

Maintenance costs

The advantage to S3 is although it has the highest capital cost, it does not require further maintenance, thereby lowering its whole-life cost. In comparison, the rock armouring options both require maintenance, the marine barrier giving a lower maintenance cost resulting from the additional erosion protection this offers to beach armouring..

Area BS and BN

The highest ranking options for Area BS and BN (due to the similarities in context) are:

- BS1/BN1 – Continued monitoring and remove radium contamination;
- BS7G/BN7G - Reinforce/replace current rock armour with on-going monitoring/radioactive material removal, and
- BS6/BN6 – Remove radium to Criterion 1, reinforce/replace and extend current rock armour to cover the sandy foreshore (strand).

Capital Costs

Monitoring and removing radium contamination from the foreshore (options BS1/BN1) has the lowest capital cost due to the lack of construction work. However, this is balanced against the open ended nature of the requirement combined with the potential for repopulation of radium from coastal erosion of landward material.

The highest capital cost is associated with the option that has the largest amount of construction work, BS6/BN6, which involves the extending of the rock armour across the foreshore.

The remaining option (BS7G/BN7G), although it has construction work, has a lower level of effort and consequently is ranked between the other two options.

Maintenance Costs

Maintenance costs are only applicable to the options that require installation of rock armouring to provide a cover system. The option with the lowest maintenance cost relates to the extended rock armouring over the foreshore. The reasoning behind this is that wave energy will be dissipated on the extended rock armouring (acting as a revetment) and thereby limiting the potential for impact on the reinforced/replaced rock armouring currently protecting the headland. Without the extended rock armouring, the reinforced/replaced rock armouring is likely to require a higher degree of maintenance with associated costs.

Sub-Area BN-Z

The highest ranking options for Sub-Area BN-Z are:

- BNZ4 – Install rock armour;
- BNZ1 – Monitor and remove radium contamination, and
- BNZ5B – Excavate localised landward ashy infill for off-site disposal with installation or rock armouring.

Capital Costs

Relative to one another, the highest capital costs is attributable to BNZ5B. This is due to the requirement for excavation, off-site disposal and import of clean fill in addition to installation of rock armour. The lowest capital cost is reflected in BNZ1 which comprises on-going monitoring. However, the duration of monitoring is currently unknown, especially if further erosion of the ashy infill were to occur.

Maintenance Costs

The relative cost of maintenance is considered to be highest for the option to continue monitoring as this is of unknown duration, especially due to the fact that the option could potentially be compromised in the longer term as the ashy infill still remains available. In contrast, the option that includes removal of ashy infill and includes rock armouring to prevent erosion is considered a more robust solution and will have minimal maintenance costs. Rock armouring would have a slightly lower maintenance score due to the presence of ashy fill still remaining directly behind any rock armouring.

4.6.5 Stage 4 Sensitivity Considerations

It is recognised that ranking the relative capital and maintenance costs per area can potentially be insensitive to understanding the financial magnitude of implementing an option over a minimum 25 year period. To understand and address these potential sensitivities, an overarching consideration has been given to the overall cost of an option in the evaluation in Section 5.

4.7 Integration and Enhancements

4.7.1 Integration Efficiencies

The attribute assessment process has defined a series of individual management options for each area. The points below highlight the efficiencies of integrating the options when considering the proposed works as a whole.

- There will be efficiencies in implementing the rock armouring in both Area H and Area S rather than employing two different techniques across two adjacent areas. For example, the import of rock, geotextiles and filter gravels can all be brought into site and installed at broadly, the same time with the same specialist plant being fully utilised across both areas, rather than bringing in new equipment for an area specific application;
- Additionally, there will be further efficiencies in rock armouring at Sub-Area BN-Z if this can be implemented in broad terms at the same time as Area H and Area S;
- The efficiencies and benefits for any offshore barrier system, such as a breakwater, extend right across the Dalgety Bay foreshore rather than to one specific area.

4.7.2 Wider Enhancements

The individual management options provide wider enhancements. For example, by effectively covering Area H by rock armouring and protecting landward radium contamination from marine erosion, the migration of any residual underlying contamination downdrift, i.e. into Area S, will be severely limited. This process effectively cuts off any potential feed of radioactive material from Area H into Area S and further downdrift. The same benefit is also valid in the case of repopulation of the Ross Plantation foreshore from radium contamination within the foreshore of Area BN.

5. Management Strategy Selection

5.1 Introduction

The selection of the management option for each area has been undertaken in consideration of three key metrics which are as follows:

- Functionality (A): this comprises the attributes identified and defined earlier in this report (Section 4) and the scoring of any one option against those attributes;
- Risk/Exposure Reduction (B): this is essentially the relative achievement of any one option against the defined health protection criteria provided in Section 2.4.1, and
- Cost (C1 and C2): this comprises not only the capital cost (C1) for any construction activities but also the longer term maintenance costs (C2) associated with any one option.

5.2 Final Management Strategy Selection Assessment

Table 5.1 below summarises the management strategy with respect to the three elements defined above.

Table 5.1 Assessment Against Key Metrics

Area/Option	A. Functionality Score (out of 50)	B. Relative Confidence of Achieving the Health Protection Criteria (✓ to ✓✓✓)	C1. Indicative Upper Bound Capital Cost (£)	C2. Indicative Maintenance Range over 25 Years (% of C1.)
Area H				
H4 – Reinforce armour stone and extend rock armour across the foreshore	34	✓✓✓	Moderate	5-10%
H7G – Reinforce armour stone, extend over foreshore and installation of a marine barrier	32	✓✓✓	Moderate to High	5-15%
Area S				
S5 – Remove radium to Criterion 1, rock armour foreshore and construct replacement slipway/jetty	31	✓✓✓	Moderate	5-10%
S7B – Remove radium to Criterion 1,build replacement slipway and rock armour foreshore and construct marine barrier	30	✓✓✓	Moderate to High	5-15%
S3 – Excavate Foreshore, dispose off-site and replace with clean import	29	✓✓✓	Very High	1-2%

Table 5.1 (continued) Assessment Against Key Metrics

Area/Option	A. Functionality Score (out of 50)	B. Relative Confidence of Achieving the Health Protection Criteria (✓ to ✓✓✓)	C1. Indicative Upper Bound Capital Cost (£)	C2. Indicative Maintenance Range over 25 Years (% of C1.)
Area BS				
BS7G – Reinforce replace current rock armour and on-going monitoring	37	✓✓	Low to Moderate	10-20%
BS1- Monitor and remove foreshore radium contamination	36	✓	Moderate	-
BS6– Remove radium to Criterion 1, improve and extend current rock armour to cover the sandy foreshore	36	✓✓✓	Low	10-20%
Area BN				
BN7G – Reinforce replace current rock armour and on-going monitoring	37	✓✓	Low to Moderate	10-20%
BN1 - Monitor and remove foreshore radium contamination	36	✓	Moderate	-
BN6 – Remove radium to Criterion 1 and improve and extend current rock armour to cover the sandy foreshore	36	✓✓✓	Low to Moderate	10-20%
Sub-Area BN-Z				
BNZ5B – Excavate localised landward infill, off-site disposal and install rock armour	36	✓✓✓	Low	10-15%
BNZ4 – Install rock armour	39	✓✓	Low	10-20%
BNZ1 – Monitor and remove foreshore radium contamination	36	✓	Included in BN	-

5.3 Discussion

The following summary discussion further defines the management options with respect to cost benefit.

5.3.1 Area H

The two short-listed approaches are nearly identical with the one having the inclusion of a marine barrier. Both options have a higher degree of confidence in achieving the health protection criteria by providing a substantive layer of cover to any underlying radium whilst at the same time preventing erosion of the landward infill. The major differentiator between these options relates to the functionality scoring and cost. With regarding to functionality, a marine barrier is considered more complex with respect to authorisations and permits as well as construction certainty. The significant cost variance between the options, however, indicates that Option H4, reinforcing the current armour stone and extending rock armouring over the foreshore, is the most cost beneficial option.

5.3.2 Area S

As for Area H, the two options for removal of radium to meet Criterion 1 and rock armouring are identical with one having the inclusion of a marine barrier. The third option comprises wholesale excavation of the foreshore and off-site disposal. All three options score well with respect to high confidence of achieving the health protection criteria. The armouring options would include removal of radium above health protection Criterion 1 below and adjacent to the existing slipways/jetty. In functional terms, excavation of all radium is considered a much more complex operation with lower construction certainty. This is reflected in the overall cost of such an operation, approximately twice that of the next highest cost (which includes a marine barrier). This leaves the two rock armouring options to be considered further and, for the same reasons as identified above, S5 of radium removal above criterion 1 and rock armouring the foreshore, is considered the most practical and cost beneficial.

5.3.3 Area BS and Area BN

Due to the similarities between these areas and their respective options, these two areas have been considered together. It is likely that in practical terms, any option undertaken on one area would also be implemented on the other.

Two of the options relate to rock armouring reinforcing/replacement to the current revetment with one removing radium to Criterion 1and extending the rock armouring over the upper sandy foreshore (strand). The third option of on-going monitoring has a lower degree of confidence with respect to achieving the health protection criteria and, longer term, is the potentially higher cost out of the options. This is not considered the most cost beneficial approach.

The rock armouring options are broadly similar with the trade off of higher confidence of achieving the health criteria being off-set against functionality. In undertaking preparation for the armouring works, radium would be removed to meet Criterion 1. Extending the rock armouring across the sandy foreshore would ensure the vast majority of radium is isolated, but would have the significant result in the loss of future amenity, hence the slightly reduced functionality score. However, the thickness of installed rock armouring across the sandy foreshore could potentially raise the foreshore to an elevation comparable to that of the current boat park. This could allow for some degree of amenity recovery, for example, by designing in the provision of a pathway along the upper surface of the rock armouring.

On balance, the option to address risks from radium material in the Boat Park Bay South and North by removal of radium with activities above Criterion 1 and then rock armouring across the sandy foreshore is the most cost beneficial. This is due to the higher confidence in achieving the health protection criteria at similar cost to the revetment reinforcement and continued monitoring and recovery options.

5.3.4 Sub-Area BN-Z

The purpose of work within the localised Sub-Area BN-Z is to remove the potential for ongoing erosion of radium from within the landward infill. The approach of monitoring and removal of radium from the foreshore is likely to be something undertaken for the wider Area BN works and so no additional cost has been provided. This option alone is not a particularly durable long term solution.

In contrast, the engineered solutions comprising the remaining two options do have associated costs and maintenance requirements. Both options prevent the migration of landward infill, but the added removal of radium will have a wider benefit, i.e. landward as well as foreshore. Although a slightly more expensive option in the short term, on balance, this is the more cost beneficial approach longer term.

5.4 Recommended Management Strategy

In consideration of the above appraisal the recommended Management Strategy for the management of radium contamination within the Site is summarised in Table 5.2 and set out in more detail in the subsequent sections.

Table 5.2 Recommended Management Strategy

Area	Option ID	Option Summary
Area H	H4	Reinforce/replace coastal armour stone and extend rock armour over the foreshore
Area S	S5	Remove radium to Criterion 1, rock armour over the foreshore and construct replacement slipway
Area BS	BS6	Remove radium in line with Criterion 1, reinforce/replace current coastal rock armour and extend over the sandy foreshore
Area BN	BN6	Remove radium in line with Criterion 1, reinforce/replace current coastal rock armour and extend over the sandy foreshore
Sub-Area BN-Z	BNZ5B	Excavate localised landward infill, dispose off-site and install rock armour

5.5 Management Strategy Preparatory and Construction Works Overview

5.5.1 Area H

The Management Strategy is detailed further below and illustrated on Drawing 10.

H4 - Reinforce Armour Stone and Extend Rock Armour Over All of Foreshore

Preparatory Works

Preparatory works will include the protection of the grassed headland area that will form a working platform from which place additional armour stone to the upper headland. This will likely require the grassed area to be temporarily covered with protective geotextile and stone. This will also act to mitigate against any potential cross contamination from works onto the grassed surface. Access to this area will therefore be restricted during the works.

Additionally, large oversize materials will be removed from the beach area for incorporation into the main works at a later date. The existing armour stone, which is locally failing, will be carefully removed, assessed and stored for re-use or potentially the new armouring may be constructed in front of the current armour stone. There may be a requirement to re-profile the crest of the existing slope to allow later placement of geotextile across the foreshore.

Concurrently, the new rock armour will be placed at or around low tide to aid in the protection of the works with the remainder placed strategically on the beach for ease of future placement.

Radium contamination in excess of Criterion 1 encountered during the reprofiling work will be characterised, segregated and packaged for off-site disposal at an appropriate licensed facility.

Main Works

The installation of the geotextile membrane will be from the top of the re-profiled slope, secured in an anchor trench. The geotextile will then be rolled out across the foreshore at low tide. The seaward edge of the geotextile will be anchored at or around the low tide mark in a trench leaving an overlap of 2 to 3 m. Before the tide begins to flood, the first layer of filter/cover stone will be placed with the overlap turned back to landward. The protection armour already stockpiled on the beach will then be placed on the geotextile progressing up the beach profile. Each panel will be completed sequentially with an overlap of geotextile.

Arisings from the excavation of the anchor trenches will be characterised and if necessary removed from site for disposal at an appropriately licensed facility. Movement off site will be via road in accordance with a Traffic Management Plan. The programme will be dictated by tide times, and daylight restrictions. Sections of work will be completed in strips corresponding to the roll width of the geotextile. Upon completion, any enabling works will be decommissioned with the grassland area being restored.

5.5.2 Area S

The management strategy elements set out below are summarised on Drawing 11.

S5 - Remove Radium to Criterion 1, Build Replacement Slipway and Rock Armour Foreshore

Preparatory Works

The preference for this option is to deliver the majority of materials by sea. This would not be practical for the replacement slipway construction, but should be feasible for all the armouring materials. Effective transport routes would first be established with any required enabling works such as temporary moorings being authorised and constructed. The existing slipways and jetty are in a poor condition and radium containing material are suspected below these structures. It is proposed these structures be removed to enable recovery of underlying high activity radium material and new and more durable replacements constructed. Additionally, where agreed with the regulatory authorities, the foreshore will be turned to the full depth of known radium contamination and within the constraints of the foreshore environment (seawater saturated foreshore). This will require installation of temporary works to prevent the migration of radium via coastal processes. It is envisaged that the foreshore will be divided into cells with the surface and upper layer, likely to be in the region of 100 mm, surveyed in each cell to identify and remove radium >40 kBq. Once any localised (>40 kBq) radium has been removed, the upper layer will be removed and temporarily stockpiled adjacent to the cell to allow monitoring and surveying to be completed to the full depth of known contamination. The recovered radium contamination will be characterised and packaged for appropriate offsite disposal. Subject to regulatory approval, the excavated foreshore materials adjacent to each cell will be replaced in the same thickness as excavation with verification surveys completed upon each layer. This will prepare the foreshore by meeting Criterion 1 prior to rock armouring.

Main Works

The existing slipways and jetty will be removed in a phased manner. Removal of radium contamination exceeding Criterion 1 will take place immediately below and adjacent to the demolished structures. The main work will be carried out as for the rock armouring of the foreshore detailed in H4 above. The only difference will be the construction of a new precast slipway or jetty, to replace the existing, above the geotextile layer with the rock armour placed around.

5.5.3 Area BS and BN

BS6 – Remove Radium to Criterion 1, Improve and Extend Rock Armouring to Cover the Sandy Foreshore (strand)

Preparatory Works

Preparatory work will include the protection of the grassed headland area as this will be required for access to place the armour stone and as a platform to commence work from. This will likely require the areas to be temporarily covered with protection geotextile and stone. It will also mean that access to this area will be restricted during the works. Large oversize materials will be removed from the beach area for incorporation into the works at a later date. The existing rock armour will be carefully removed and stored for re-use. The existing slope landward side will be re-profiled to allow placement of the protection geotextile with any radium contamination segregated, characterised and packaged for off-site disposal. The rolls of geotextile will then be placed landward side for deployment. Concurrently the new rock armour will be placed at or around low tide to aid in the protection of the works with the remainder placed strategically on the beach. Additionally, the foreshore will be turned to the full depth of known contamination and within the constraints of the foreshore environment, e.g. allowing for the presence of saturated ground conditions and allowing for the detection efficiencies of monitoring equipment with potentially wet material. The purpose will be to remove radium contamination (>40 kBq Ra-226) prior to rock armouring the foreshore.

Main Works

As elsewhere the protective geotextile will be installed from the top of the slope and will be secured in an anchor trench. The geotextile will then be rolled out at low tide across the profile of the upper sandy beach. This will be anchored in a trench leaving an overlap of 2 to 3 m. Before the advancing tide returns the first layer of filter/cover stone will be placed with the overlap turned back to landward side. The protection armour already stockpiled on the beach will then be placed on the geotextile progressing up the beach profile. Each panel will be completed sequentially with an overlap of geotextile.

Arisings from the excavation of the anchor trenches will be characterised and if necessary removed from site for disposal at an appropriately licensed facility. Off site movement will be via road in accordance with a Traffic Management Plan. The programme will be dictated by the tide times and daylight restrictions and sections of work will be completed in strips corresponding to the roll width of the geotextile. Upon completion, the enabling work will be decommissioned with the landward area being restored.

BN6 – Improve and Extend Rock Armouring to Cover the Sandy Foreshore (Strand)

This option is identical to item BS6 above.

BNZ5B - Excavate Landward Infill Off-site Disposal and Install Rock Armour

Preparatory Works

The main pre-commencement activities associated with this option will involve establishing transport routes into and out of the site and preparing the area for the packaging and loading of materials. Due to the relatively small quantity (an indicative estimate of 100 m^3 of landward radium contamination is to be removed) the most practicable option for the transport of all materials is via road. A compound, loading area and packaging area will be required close to the excavation but sufficiently landward as to not be flooded or damaged by storm events. The excavation area will also need to be protected from inundation from the sea to ensure that radium contamination is not washed out during the works. These temporary works will be essential to the undertaking of the works. The materials placed as armouring will be imported early to be used for protection of the works during construction.

Main Works

The main works will comprise the excavation of materials. Due cognisance will be applied to the tides and the temporary works protection will be maintained throughout. The excavation will be undertaken commencing from the seaward side to a sufficient extent to allow for removal of sufficient material and to allow for the use of the excavation for an anchor trench. Materials will be characterised chemically and radiologically before loading and sentenced for appropriate disposal. The materials will be securely stored awaiting transport and transport arranged to minimise impacts to the local community. The resultant excavations will be backfilled with suitable imported granular fill and surface materials reinstated appropriately. Following completion of the excavation and reinstatement work the temporary works protection materials will be re-used as a sea defence to the landward edge of the beach. A geotextile protective layer will be placed beneath the armouring to ensure its efficacy in terms of preventing future erosion.

5.6 Maintenance for Management Strategy

The Management Strategy maintenance requirement is summarised below.

5.6.1 Rock Armouring (Cover System/Reinforcement)

On completion of rock armouring, the maintenance requirements will be similar to any coastal engineered protection scheme. There should be an annual monitoring of defences to ensure their general suitability. It is expected that there may be some requirement to replenish small amounts of armour stone on a rolling 5 year programme with the overall scheme having a minimum 25 year design life if maintained appropriately. Additionally, material is likely to be deposited on the foreshore ultimately providing additional cover and protection.

6. Outline Performance Specification

6.1 Introduction

The following section provides an outline specification for the recommended management strategy elements. The specification will need to be further developed and refined during design development..

A performance specification provides flexibility with respect to items such as: materials; processes; work integration and so forth. It also allows the final tailoring of the option to suit site conditions and development of appropriate performance criteria and verification procedures.

6.2 Performance Specification

6.2.1 Area H

Across Area H, the management strategy must ensure that radium within the foreshore and potential landward radium contamination that may be made mobilised through coastal erosion cannot come into contact with beach users either by direct (skin) contact, inhalation or ingestion. This should be achieved by the installation of a cover system comprising a geotextile lining and rock armouring. The geotextile liner must be able to prevent the migration of 'fines' (≥1 mm diameter sediment particles) and must be of sufficient robustness so as to meet the minimum design life requirements given in Section 7.2.6. A suitable protection layer is also required to ensure that the geotextile liner is protected during and after installation of the rock armour. The rock armouring must be of sufficient thickness to provide effective shielding and ensure potential doses are at or below the PHE Criterion 2 and be installed to such a thickness and in such a manner so as to prevent degradation given the local coastal environment. The work should be designed and implemented in accordance with the relevant standards; a non-exhaustive list of which is provided below. Future maintenance requirements should be minimised through design with a focus on longevity.

6.2.2 Area S

Across Area S, the management strategy must ensure that foreshore radium cannot come into contact with beach users either by direct contact, inhalation or ingestion, through removal of materials with >40 kBq Ra-226 and the installation of a cover system comprising geotextile lining, rock armouring and a new purpose built replacement slipway. The geotextile liner must be able to prevent migration of 'fines' (≥1mm) and must be of sufficient robustness so as to meet the design life requirements given in Section 7.2.6. A suitable protection layer is also required to ensure that the geotextile is protected during and after installation of the rock armour. The rock armouring must be of sufficient thickness to provide the shielding cover necessary to reduce the potential effective doses to or below the PHE Criterion 2 and be installed to such a thickness and in such a manner so as to prevent degradation given the local coastal environment. The work should be designed and implemented in accordance with the relevant standards; a non-exhaustive list of which is provided below. Consideration of access requirements to both the jetty, and as a result the foreshore, should be given due consideration in the design. Future maintenance requirements should be minimised through design with a focus on seeking longevity.

6.2.3 Area BS and Area BN

The identical management strategy for Area BS and BN comprises removal of radium above 40 kBq, rock armour reinforcement/replacement and rock armouring over the sandy foreshore. The rock armouring reinforcement/replacement must ensure that potential radium contamination landward that may mobilise through coastal erosion cannot come into contact with beach users. It is envisaged that a contractor will install a geotextile liner along with suitable protection layer. This must be of sufficient robustness to meet the design life requirements given in Section 7.2.6 and prevent migration of 'fines' (≥1 mm). The rock armouring must be installed to such a thickness and in such a manner so as to prevent degradation given the local coastal environment. The work should be designed and implemented in accordance with the relevant standards; a non-exhaustive list of which is provided below. Future maintenance requirements should be minimised through design with a focus on seeking longevity.

6.2.4 Sub-Area BN-Z

The management strategy for Sub-Area BN-Z requires the excavation of sufficient landward ashy fill followed by replacement with suitable clean fill. The installation of rock armouring to prevent future migration of radium onto the foreshore and to protect the reinstated materials will also be required. The rock armouring will need to include a geotextile of sufficient robustness to meet the design life requirements of minimum 25 years and prevent migration of fines (≥1 mm) and should include a suitable protection layer. The rock armouring must be installed to such a thickness and in such a manner so as to prevent degradation given the local coastal environment. The rock armouring must have a gradual termination to prevent end-point washout as has occurred in Sub-Area BN-Z where the wider Area BN rock armouring abruptly terminates. The work should be designed and implemented in accordance with the relevant standards; a non-exhaustive list of which is provided below. Future maintenance requirements should be minimised through design with a focus on longevity.

6.2.5 Specification and Guidance Documentation

Table 6.1 Relevant Specification and Guidance Documentation

Title	Author	Date	Reference	Relevance
Coastal Engineering				
The Rock Manual - The Use Of Rock In Hydraulic Engineering (2nd edition)	CIRIA	2007	C683	Section 6.0 (design), 9.0 (construction), 10.0 (monitoring)
Maritime Works. Code Of Practice For Planning And Design For Operations	BSI	2013	BS 6349-1-1	
Maritime Works. Code Of Practice For Assessment Of Actions	BSI	2010	BS 6349-1-2	
Maritime Works. Code Of Practice For Geotechnical Design	BSI	2013	BS 6349-1-3	
Maritime Works. Code Of Practice For Materials	BSI	2013	BS 6349-1-4	
Maritime Works. Code Of Practice For The Design Of Shipways And Sea Locks	BSI	2013	BS 6349-3-1	Section 7 - Slipways

Table 6.1 (continued) Relevant Specification and Guidance Documentation

Title	Author	Date	Reference	Relevance
Maritime Works. Guide To The Design And Construction Of Breakwaters	BSI	1991	BS 6349-7	
Beach Management (2nd edition)	CIRIA	2010	C685	
Sea Walls - Survey Of Performance And Design Practice	CIRIA	1986	TN125	
Guidance On The Management Of Landfill Sites And Land Contamination On Eroding Or Low-Lying Coastlines	CIRIA	2013	C178	Useful summaries: Section 1 - legislation and regulation, Section 8 - evaluating performance and effects.
Seawall Design	CIRIA	1992	-	Section 6 (design)
General Remediation Guidance				
Contaminated Land Research Report 11 - Model Procedures For The Management Of Land Contamination	EA	2004	CLR11	
SAFEGROUNDS: Approach to Managing Contaminated Land on Nuclear-Licensed and Defence Sites – An Introduction	CIRIA	2009	W27	
SAFEGROUNDS: The UK Regulatory Framework for Contaminated Land on Nuclear-Licensed and Defence Sites	CIRIA	2010	W36	
Remedial Treatment For Contaminated Land Volume V: Excavation And Disposal	CIRIA	1995	SP105	
Cover Systems For Land Regeneration	BRE	2004	BRE465	
Barriers, Liners And Cover Systems For Containment And Control Of Land Contamination	CIRIA	1996	SP124	
Asbestos In Soil And Made Ground: A Guide To Understanding And Managing Risks	CIRIA	2014	C733	

6.2.6 Design Life

The minimum design life for the management strategy is 25 years from the date of completion of the constructions works, as certified by a Substantial Completion Certificate. It is recognised that an element of maintenance will be required in order to ensure the minimum design life can be robustly achieved and this should be considered and included within the design.

6.2.7 Extended Design Life Considerations

Consideration shall be given to the cost benefit of extending the minimum design life of the management strategy. The extent of the design life extension and the lifetime costs, in today's value, should be clearly defined to determine whether or not there is a quantifiable value added benefit.

6.3 Waste Management

The management of waste is an integral part of the project and its efficient management is essential, as detailed below.

6.3.1 Permit to Accumulate and Dispose of Radioactive (Radium) Waste

A permit to accumulate and dispose the recovered radium will be required. The permit will stipulate the requirements for accumulation, storage and disposal of radium, which will include the following key aspects:

- Operation of a management system, organisational structure and resources that are sufficient to achieve compliance with the authorisation;
- Consultation with Radiation Protection Advisers or other qualified experts to achieve compliance;
- Provision of written operating procedures for radioactive waste management;
- Supervision of radioactive waste disposal by suitably qualified and experienced named persons;
- Use of best practicable means to minimise radioactive waste;
- Disposal of radioactive waste in a manner which minimises the radiological effects on the environment and the public;
- Establishment and maintenance of adequate systems and equipment to meet the requirements of the authorisation;
- Prevention of loss or escape of radioactive waste;
- Notification of authorities in the event of loss or escape of radioactive waste;
- Collection and retention of records pertaining to radioactive waste;
- Provision of information; and
- Sampling and analysis of waste.

6.3.2 General Waste Management

The following measures should be adopted, unless agreed otherwise with the Local Authority, when managing material and waste stockpiles at construction work sites:

- Storage areas to be clearly marked;
- Materials will be stored in suitable containers that are appropriately labelled with fitted lids, taps and tops in good condition;
- Control measures will be put in place and/or spill response kits/materials will be located near to bulk stores;
- Materials will be stored and protected against breakage, vandalism, theft or inundation/flood damage;
- Different grades of soil and waste types will be separated;

- So far as possible having regard to the nature of the works materials will be stored away from sensitive site plant and environmental receptors such as watercourses, and
- Materials will be stored away from main site access roads.

Radioactive (radium) Wastes will be stored in accordance with the Permit to Accumulate and in appropriate containers which will be adequately signed.

6.3.3 Waste Segregation and Management

The various wastes generated during the implementation of the management strategy, will be segregated to ensure appropriate characterisation is undertaken and thereby appropriately reduce volumes of materials for off-site disposal.

Stockpiling of Exempt and Controlled Waste

A stockpile area will be required to hold waste arisings pending off-site disposal. The stockpile should be positioned so as to minimise wagon movements across unpaved ground, thereby minimising the potential for the cross contamination on site and onto public highways. Installation of a wheel wash may be necessary.

The stockpile areas will be secured with HERAS fencing.

Storage of Low Level Radioactive Waste

To comply with the Environmental Permit measures will be taken to:

- Prevent loss or escape of accumulated radioactive waste;
- Prevent access to radioactive waste by any unauthorised person;
- Keep radioactive waste in a container in a store both of which are:
  - Constructed, maintained and used so as to prevent the loss or unauthorised use removal of the waste;
  - Constructed of non-combustible materials;
- Do not contain or are located close to any corrosive, explosive or flammable material; and
- Are clearly marked with the word “Radioactive” and with the ionising radiation symbol complying with BS 3510 and any other information necessary for the identification of the waste present.

6.3.4 Waste Characterisation

Waste sentencing procedures will be agreed with SEPA and disposal sites prior to the accumulation of wastes. Activity concentrations of waste will be measured across fixed volumes of waste using both direct probe measurement (employing an appropriate calibration factor) and confirmatory laboratory analysis. Sentencing procedures will be pivotal to the management of radioactive wastes.

6.3.5 Waste Disposal

Radioactive Wastes

During the remediation works there will be a need to transport radium contamination, including wastes, to and from the site by road. This material is expected to comprise:

- Calibration sources (to and from the site);
- Samples of contaminated materials to analysis laboratories;
- Low Level and Exempt Waste disposal from the site;
- Controlled Waste that is exempt from the provisions of the Radioactive Substances Act 1993 but not from the provisions of Dangerous Goods legislation.

Legislation

The legislation applicable to the transport of radioactive material, including low level and intermediate level waste, is the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009, as amended. To ensure compliance with the legislation, a RPA advisor will need to assess movements of radioactive material and specify movement categorisation and container types to be used.

Packaging

Different standards of packaging are required for transporting radium contamination depending on the classification and hazard of the material. For the range of materials expected to require transport during the remediation works the types of packages required are:

- Excepted packages with make-up approved by a suitably qualified and experienced person;
- Industrial Packages meeting the requirements of the IAEA Regulations for the Safe Transport of Radioactive Material (TS-R-1).

Some low hazard material may be permitted to be transported in non-approved packaging if it meets the conditions specified in legislation. The RPA will provide advice on container requirements. A Dangerous Goods Safety Adviser will be required.

Non Radioactive Wastes

Non radioactive wastes materials suitable for recycling such as scrap metal will be temporarily stockpiled on-site prior to removal by road going vehicle to an appropriately licensed facility. Wastes unsuitable for recycling such as asbestos, plastic and wood will be stored in covered stockpiles and/or skips prior to export off-site to an appropriately licensed facility.

All waste movement will need to be recorded by those undertaking the works and handled in accordance with Duty of Care and Hazardous Waste Regulations where appropriate. Duty of Care and Consignment Notes will be stored on site throughout the project. To mitigate the impact of waste the following measures will be employed as required:

- Waste Management Plan;
- Segregated skips and/or stockpiles for waste disposal and recycling;
- Secured in the case of radiological wastes in accordance with the accumulation permit;

- Suitable position, identification and labelling of waste storage areas;
- Use of suitable waste storage containers e.g. double skinned storage tanks for waste oil, and
- Management throughout works under the materials management plan prepared for the site.

6.4 Outline Verification Requirements

Verification of the construction works will be dependent upon the final management options employed. Broadly speaking this can be summarised as follows:

- Where rock armouring cover is utilised, limited verification monitoring is considered necessary to demonstrate successful installation. This purpose of the verification monitoring will be to show there is no radium contamination present across the newly installed rock armour, above the agreed verification criteria. This work will be required for Areas H, S, BS and BN;
- Verification of rock armouring installation will require design drawings, as-built drawings, geo-referenced progression photography, cut-fill surveys and volumes, QA/QC documentation, for example, in relation to the installed geotextile liner, grading certificates and so forth.

7. Management Strategy Preliminary Programme

7.1 Programme

7.1.1 Introduction

The implementation programme needs to consider the main tasks:

- Stakeholder consultation;
- Design development of preferred scheme;
- Planning application and environmental impact assessment preparation and approval;
- Permits and licences;
- Advanced implementation of the construction works for Sub-Area BN-Z;
- Main construction works procurement, and
- Main construction works implementation.

A brief commentary for some of the key elements is provided below.

7.1.2 Implementation Group Consultation and Design Development

The management strategy and implementation programme are currently at a high level and further detailed development is required in consultation with and through the Implementation Group and other key stakeholders. Progression of the design (for example the size and extent of armouring and location of any replacement slipway etc) is required to inform the planning and environmental impact assessment and the application for necessary permits and licences to undertake the works. The period for this work is dependent on the support of these stakeholders and regulatory bodies.

Detailed design development will also require coastal processes modelling so that the proposed armouring systems can be designed for optimum durability.

7.1.3 Planning and Environmental Impact Assessment

At this stage it is difficult to be precise about the length of time required to prepare the EIA, due to determining the nature and extent of environmental monitoring required to inform the baseline, and some of this may be seasonally dependent. This is particularly the case for any marine ecology work, which should be carried out within the April to September window. Such fieldwork would be informed by the available data from desk-based sources, but as a minimum will need to include an initial Phase 1 survey. Such a survey would then confirm whether additional targeted species and habitat surveys are required to inform the EIA.

7.1.4 Procurement

The procurement route for the works is not yet defined so the programme requires clarity in this regard.

7.1.5 Implementation

A summary programme for implementation is provided in Table 7.1. This considers both a 'feasible' delivery programme which assumes a reasonable period for enabling activities and procurement and a 'contingency' programme which factors in potential delays in enabling activities or procurement.

It should be noted that due to the coastal environment and other preferential working factors (e.g. daylight working time), the construction work is best programmed to take place during a summer period. The exception would be Sub-area BN-Z which is largely above high tide and could be completed during the autumn or spring. Sub-area BN-Z has been identified as a priority area for implementation of Stage 1 of the Management Strategy, in advance of the main works to other areas.

Stage 2 of the main works would be to the headland beach and the western part of the slipways area and programmed for summer 2016. With very favourable enabling and procurement programming in may be possible to bring this forward to summer 2015 but 2016 is considered more realistic. With protracted delay the contingency date would be summer 2017.

Stage 3, management works to the remaining areas, would follow the summer after stage 2 is completed.

An indicative sequencing plan for the construction works is provided as Drawing 14. The extent of the proposed works is shown on Drawing 15.

Table 7.1 Summary Implementation Programme

Key Stage	Feasible Programme Dates	Contingency Programme Dates	Constraints
Enabling Activities			
Stakeholder consultation	Jun 14 - Sep 14	Jun 14 - Jan 15	Stakeholder and landowner support and co-operation delayed.
Design Development	Sep14 – Nov 14	Sep14 – Mar 15	Potential delay depending on stakeholder and regulator inputs.
Planning and EIA	Sep 14 – May 15	Feb 15 – Oct 15	Potential delay to planning/EIA process and approvals.
Stage 1 Advance Works Boat Park North			
Design and regulatory agreement	Sep 14 - Nov 14	Sep 14 – Mar 15	Feasible programme based on minimum of planning and regulatory involvement, contingency programme assumes planning permission and complex regulatory agreement.
Procurement	Nov 14 – Mar 15	Mar 15- Jul 15	Assumes straightforward procurement.
Implementation	Mar15 – Jun 15	Mar 16 – Jun 16	Contingency programme assumes procurement not completed to enable implementation to start in summer 2015.
Stage 2 and 3 Main Works Design and Procurement			
Detailed design and regulatory approvals	Oct 14 - Jan 15	Jan 15 – Nov 15	Delayed and protracted approvals.
Contract documents and procurement	Nov 14 – Jul 15	Nov 15- Jun 16	

Table 7.1 (Continued) Summary Implementation Programme

Key Stage	Feasible Programme Dates	Contingency Programme Dates	Constraints
Stage 2 Implementation headland and slipways Phase 1	May 16 - Sep 16	May 17 - Sep 17	Works need to be completed during summer period. Work could potentially be brought forward to summer 2015 if preceding activities can be completed earlier. Contingency programme has works delayed to summer 2017.
Stage 3 Implementation slipways phase 2 and boat park	May 17- Sep 17	May 18- Sep 18	To follow summer after Stage 2, may be potentially be brought forward to summer 2016 or delayed to summer 2018 on contingency programme.

8. Key Risks

8.1 Purpose

The purpose of identifying and ranking key risks that may be realised during the life-cycle of the Management Strategy is to allow mitigation measures to be implemented. This may take the form of specific actions, such as advancing consultation processes or completing a specific piece of work, or may take the form of financial provisioning.

The key risk considerations in relation to the Management Strategy are summarised in Table 8.1 below:

Table 8.1 Key Risk Considerations

Risk Group	Risk Description	Realisation of Risk	Action Plan
Detailed Design	Planning conditions require EIA to be undertaken which has wider environmental considerations	Environmental surveys and consultation increase implementation programme	Work closely with Fife Council to agree EIA scope prior to commencing detailed design
Detailed Design	The proposed detailed design verification criteria is not yet agreed with Regulator	Potential for protracted negotiations resulting in delays to programme and potential for reconsideration of remedial processes end-point	Agree with SEPA as part of detailed design work
Consents/Approvals	Delayed agreement, or no agreement, to required permit/authorisations and/or licenses (e.g. SEPA, Scottish National Heritage, Forth Ports Authority, Marine Scotland etc.)	Potential for protracted negotiations resulting in delays to programme and potential for reconsideration of management strategy	Engage with SEPA Permitting Group to secure agreements
Consents/Approvals	Delayed agreement, or no agreement, from landowners regarding proposed management strategy	Potential for protracted negotiations resulting in delays to programme and potential for reconsideration of management strategy	Seek early agreement through Implementation Group to secure agreements
Consents/Approvals	Unable to gain regulatory consent to specific reuse/redeposition of foreshore materials	Reworking of Management Strategy and adoption of revised strategy with cost increase and programme delay	Seek early engagement to secure agreements through Permitting Group
Excavation and Disposal	Variation in beach thickness and amount of contamination	Increased cost and programme delay	Further SI and characterisation as part of detailed design, risk management during contract implementation
Excavation and Disposal	Disposal routes available for both high activity (>40kBq) and lower activity radium	Potential amendment to strategy	Engagement with regulators and owners of suitable disposal routes

9. Summary and Recommendation

9.1 Summary

Following on from the identification of outline management options, a Management Strategy has been developed to derive the most effective, practicable, and proportionate means for ensuring the health protection criteria recommended by PHE are met and the risk associated with radium within the foreshore at the Dalgety Bay site is managed in the long term.

The process has involved evaluation against a number of attributes and defined a number of potential management strategy options. Based on scoring against these attributes the short-listed options have been further assessed against cost and the ability of the solution to meet the defined health protection criteria.

The evaluation has been informed by a considerable body of site specific information and studies including:

- The extensive current monitoring and radium recovery programme;
- Site investigation;
- Coastal processes review; and
- Human health risk assessment.

9.2 Recommendation

The recommended Management Strategy for foreshore areas within the Dalgety Bay site comprise initial works to remove localised landward radium contamination and installation of coastal protection armour in sub-area BN-Z (part of the Boat Park North). The main works to the remainder of the site will comprise:

- Replace/reinforce existing coastal armour protection to landward areas to minimise the potential for erosion and loss of landward contamination into the foreshore environment;
- Removal of high activity (>40kBq) radium material from selected areas of the foreshore (to meet health protection Criterion 1);
- Limited reprofiling of beach/foreshore areas to accommodate a rock armour cover system; and
- Placement of a rock armour cover system over targeted areas to isolate remaining radium containing material (to meet health protection Criterion 2).

The work, by area, identified in this report are shown on Drawing 15 and summarised in Table 9.1 below:

Table 9.1 Recommended Management Strategy by Area

Area	Option ID	Strategy Summary
Headland	H4	Reinforce/replace coastal armour stone and extend rock armour over the foreshore.
Slipways	S5	Rock armour over the foreshore and construct replacement slipway, removal of radium in excess of Criterion 1 below the area to receive armour.
Boat Park Bay South	BS6	Reinforce/replace current coastal rock armour and extend over the sandy foreshore, removal of radium in excess of Criterion 1 below the area to receive rock armour.
Boat Park Bay North	BNZ5B Stage 1	Excavate localised landward infill beyond north end of current coastal armouring, off-site disposal and install rock armour.
	BN6 Stage 2	Reinforce/replace current coastal rock armour and extend over the sandy foreshore, removal of radium in excess of Criterion 1 below the area to receive rock armour.

9.3 Key Implementation Requirements

The timely detailed development and implementation of the Management Strategy is dependent upon a number of key enablers which necessitate a strong collaborative approach between all parties within the Implementation Group. These include:

- A Management Strategy implementation approach agreed with key stakeholders. This broad requirement includes:
  - agreement on roles and responsibilities, especially with SEPA and Fife Council as key regulators;
  - collaborative working through the Implementation Group DIO, SEPA, Fife council and landowners) during the detailed design development (e.g. the nature and extent of armouring, detail of replacement slipway etc.); and
  - basic necessities for implementation, such as landowners facilitating site access.
- Timely provision of the necessary permits, consents and licences through the SEPA Permitting Group with SEPA acting as the co-ordination body for the applications;
- A proactive and responsive planning environment. This is particularly important given the potential programme limitations to implementation from the various ecological designations;
- Availability of disposal routes for differing radium waste streams to be confirmed prior to and during implementation; and
- Confirmation of roles and responsibilities regarding the downstream maintenance and routine monitoring and agreement of the verification criteria.

9.4 Key Post Implementation Aspects

In advance of implementation, the Implementation Group will need to confirm roles and responsibilities regarding the downstream maintenance and routine monitoring and agree the verification criteria.

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List of Annexes

Annex A
Regulatory Considerations

4 Pages

Regulatory Considerations

There are wide ranging regulatory considerations for the remediation of radioactive contamination at Dalgety Bay. Regulations range from UK wide primary legislation (Acts), Scotland specific primary legislation (Acts), devolved secondary legislation (Scottish Statutory Instruments), Statutory Guidance and wider European directives. The various regulatory considerations with respect to any proposed remediation at the site are summarised under the following headings and will especially need careful consideration at the detailed design stage of to implement the Management Strategy.

Legislation on Contaminated Land

The contaminated land regime is set out within Part 2A of the Environmental Protection Act (EPA), 1990. Radioactive contaminated land regulations were introduced in Scotland by the Radioactive Contaminated Land (Scotland) Regulations 2007 and amended by the Radioactive Contaminated Land (Scotland) (Amendment) Regulations 2007 and the Radioactive Contaminated Land (Scotland) Amendment Regulations 2009.

These regulations are in turn supported by Statutory Guidance issued by the Scottish Government (SG, 2009). The definition of contaminated land which applies to radioactive contaminated land is:

> *"any land which appears to SEPA to be in such a condition, by reason of substance in, on or under the land, that –*
>
> *(a) significant harm is being caused or there is a significant possibility of such harm being caused; or*
>
> *(b) significant pollution of the water environment is being caused or there is a significant possibility of such pollution being caused";*

Central to the regulatory system is a rigorous procedure of risk assessment which is used to determine the existence of radioactive contaminated land according to the definition.

Legislation on Radioactive Waste Management

There is a broad framework in place for radioactive waste management. The framework is based upon Scottish, UK, European Union (EU) and international policy and covers not only the radioactivity of a waste but the non-radioactive properties also. The broad framework is relevant for nuclear licensed and non-licensed sites.

Within Scotland, SEPA regulates disposal of radioactive wastes in Scotland under the Radioactive Substances Act (1993).

Legislation on Health and Safety

Relevant Health and Safety legislation for work at Dalgety Bay comprises:

- Health and Safety at Work Act 1974;
- Construction (Design and Management) Regulations 2007;
- Control of Substances Hazardous to Health Regulations 2002;
- Control of Substances Hazardous to Health (Amendment) Regulations 2003;
- Control of Substances Hazardous to Health (Amendment) Regulations 2004;
- Ionising Radiations Regulations 1999; and

- Management of Health and Safety at Work Regulations 1999.

Legislation on Water Resources (Water Framework Directive)

- Environmental Assessment (Scotland) Act 2005;
- Environmental Impact Assessment (Scotland) Regulations 1999; and
- Environmental Impact Assessment (Scotland) Amendment Regulations 2002.

Legislation on Environmental Damage and Liability

- Environmental Liability (Scotland) Regulations 2009.

Legislation on Transport of Radioactive Materials and Dangerous Goods

- Radioactive Material (Road Transport) (Definition of Radioactive Material) Order 2002; and
- Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009.

Planning Regime

The proposed remediation of contamination at Dalgety Bay will require planning permission to be granted by Fife Council. Such an application would be made in accordance with the provisions of Town and Country Planning (Scotland) Act 1997, and other relevant legislation.

Preliminary consideration has been given to whether any remediation proposals are likely to constitute development that requires to be accompanied by an *'Environmental Impact Assessment'* (EIA). EIA is a requirement of EC Directive 97/11/EC *'The assessment of the effects of certain public and private projects on the environment'*, which amended EC Directive 85/337/EC. The amended Directive was implemented in Scotland by the Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2011 (the EIA Regulations) and advice on the Regulations is provided by Circular 3/2011. Further technical advice is provided by PAN 58 *'Environmental Impact Assessment'*.

Although it is proposed that the position be formally confirmed by the seeking a *'Screening Opinion'* from Fife Council, AMEC considers that the Management Strategy falls within the requirements of Item 10 (m) of Schedule 2 of the 2011, which refers to all development that involves *"Coastal work to combat erosion and maritime works capable of altering the coast through the construction, for example, of dykes, moles, jetties and other sea defence works, excluding the maintenance and reconstruction of such works"*.

Local planning authorities are required to provide a *'Screening Opinion'* within 3 weeks of receipt of a *'Screening Request'*. For the Dalgety Bay project, since AMEC considers that EIA would be an inevitable requirement, it is suggested that this is set out in the screening request letter, and that Fife Council be simply asked to confirm the position.

The planning application will also need to relevant national, regional and local development plan policy. The extant national planning policy context for Dalgety Bay is set out in the National Planning Framework (NPF) and Scottish Planning Policy (SPP). NPF2 was published in 2009, although this has now been updated by NPF3, the final version of which is expected in June 2014. SPP was adopted in February 2010, but a review was announced in September 2012 and the Draft SPP published in April 2013 in conjunction with NPF3. A SPP Position Statement was published in January 2014 and the final SPP is expected in June 2014.

At the regional level, Fife is part of SESplan, the strategic development planning authority for Edinburgh and South East Scotland, the Strategic Development Plan (SDP) for which was approved on 27 June 2013. Also relevant is the Fife Structure Plan, the approved modifications for which were published in June 2013. The intention is for Structure Plans to be phased out by the SDP, but for now the Fife Structure Plan remains extant policy.

At the local level, the extant development plan consists of the Dunfermline & West Fife Local Plan (adopted November 2012). Due consideration may also need to be given to the adopted Mid Fife Local Plan (January 2012). The adopted Local Plans covering the Fife area are to be replaced by the emerging Local Development Plan (LDP), FIFEplan. The Main Issues Report (MIR) was published in January 2013, which the Development Strategy etc consultation closed in February 2014. Work on the LDP has currently stalled to await the outcome of the additional work being undertaken on the SDP. A Proposed LDP is expected to be published in 2014 and to be adopted in 2016.

In terms of policies, there are a number that may be applicable and the development proposals would be considered in respect to each of these as part of the Planning (Supporting) Statement that would be prepared to accompany the application. Policy E6 – '*Contaminated and Potentially Unstable Land' of the* Dunfermline & West Fife Local Plan (2012) is particularly pertinent because it states *"Where development proposals involve sites where land instability or the presence of contamination is known to be present, the developer will be required to notify Fife Council of the appropriate remediation measures proposed to render the site fit for its intended use."*

The screening exercise would be followed by the *'Scoping'* process. This involves providing pertinent information regarding the development; identifying the people and environmental resources (collectively known as 'receptors') that could be significantly affected by the proposed development; and the work required to assess the likely significant environmental effects on those receptors. It would also *'scope out'* those environmental topics and receptors that are not considered likely to be significantly adversely affected.

This objective would be achieved by the preparation of a *'Scoping Report'*, which would be submitted to Fife Council for consideration. The local authority would then consult with a wide range of statutory and non-statutory bodies, together with the public, before providing its *'Scoping Opinion'*, which would then be used to inform and update the EIA process. The planning authority normally has a period of 5 weeks to do this, unless otherwise agreed between the parties.

The EIA process would continue with the gathering of additional relevant environmental baseline information, which would be utilised to inform the Environmental Statement (ES); the main document of the EIA process that would be submitted to support the planning application. The assessment of the environmental effects is also set out in ES, which in AMEC's case is based on a consistent methodology across all environmental topics. This assessment predicts the environmental effects by relating the identified value (based on a range of widely accepted parameters) of a given receptor to the magnitude of change that it is predicted to be subject to by virtue of the development proposals, once incorporated mitigation measures have been taken into account. The environmental effects can be both beneficial and adverse, and collectively these are used to make a judgement on the overall planning balance of the proposals.

Based on the management options that are emerging as the most likely to be adopted, it is likely that the following environmental topics will need to be scoped into the EIA: land quality

(incorporating ground contamination and the effects from physical processes on coastal structures); hydrology; marine ecology; landscape and visual; transportation (by road and sea); noise; and recreation. Subject to further investigation at the scoping stage it might be necessary to include other topics, i.e. air quality and historic environment, although it would be AMEC's intention to minimise the proposed scope, both in terms of the topics and number of receptors, to only those that it would be necessary and/or appropriate to include.

Once submitted, the planning authority has a statutory requirement to determine the application. For EIA development this is a period of 4 months from the date of its validation by the Council.

Legislation on Marine Environment

- Marine (Scotland) Act 2010.

Ecological Legislation

- Nature Conservation (Scotland) Act 2004;
- Directive on the Conservation of Wild Birds; and
- Directive on the Conservation of Natural Habitiats and of Wild Fauna and Flora.

Coastal Protection Act 1949

Local Authorities were granted discretionary powers to address erosion from the sea and statutory powers to regulate works carried out by others.

Annex B
Tier 1: Attribute Tables 1A and 1B and Tier 1 Attribute Scoring Assessments

15 Pages

Tier 1 Attribute Scoring Assessment

Area H (Headland)

Option H1 - Excavate foreshore, remove radioactive material and replace excavated materials

Practicality: Excavation of the beach in Area H is considered impractical, though not impossible. The foreshore within the area is only fully exposed at complete spring low tide and is completely covered during neap and spring high tides. The window for undertaking excavation and the process of excavating full depth foreshore Made Ground, which will be saturated, is therefore limited. The possible areas for screening arisings are limited and may suffer from high background activities as a result of known infilled areas. Additionally, replacement of excavated and screened materials will be made more difficult due to variable grain size of foreshore materials, tidal variance and prevailing weather conditions at the time. This option also has potential limitations due to identification of disposal routes for different radium waste streams.

Score = 2

Effectiveness for Area: The excavation of the foreshore would only remove contaminants within the Made Ground in that location. Coastal erosion processes have the potential to expose known radioactive material infilled landward and thereby recontamination of the foreshore is a possibility. This results in a low scoring for effectiveness for an excavation only option.

Score = 1

Durability: Notwithstanding the comments made above, the removal of contaminants and replacement of non-radioactive foreshore materials is considered a reasonably durable option due to the removal of contaminants of concern remaining within the foreshore with the potential to have impact to potential receptors. However, this option is limited to the efficiency of the equipment used to detect contaminants and is not considered as durable as import of clean materials.

Score = 4

Construction Certainty: Ensuring excavation sides do not slump and the base of excavation does not over-excavate into uncontaminated underlying sands together with likelihood of a very variable rockhead profile, which gives considerable uncertainty as to excavation and waste quantities, further exasperates the construction certainty of this option. Furthermore, ensuring all radium contamination has been removed from the excavated foreshore prior to replacement poses difficulties with respect to equipment resolution, moisture content of materials and, ultimately, throughput. This would have a direct impact on programme. The replacement of beach materials would need careful consideration to ensure replaced materials are not simply washed away with the daily tidal processes. It is noted that in the foreshore area, the beach materials are graded, generally from larger sized materials (cobbles and gravels) down to finer sized grains (mud). This areas of the beach is also a relatively high energy environment with a steep profile meaning reduced access and a high potential for damage to ongoing/nearly completed works.

Score = 2

Coastal Processes Impact: The long term impact to any coastal processes is considered relatively minimal providing suitable and appropriate materials are replaced. Apart from the short term impacts during excavation in broad terms the foreshore will be similar in condition as

to prior to commencement. However, there is a slight risk that the disturbance will mobilise previously stable sediment however, and encourage further erosion.

Score = 2

Option H2 – Excavate foreshore and remove to site containment area, with clean import

Essentially, for the purposes of excavation and replacement, the same principles as Option H1 apply. However, there are variances which are described below.

Practicality: The screening process required in Option H1 would not be required for Option H2. However, a major drawback to this option is the requirement for locating an area that would be suitable for a containment cell and constructing the containment cell for an appropriate design life. This may necessitate the demolition of current buildings and carries with it the potential for long-term perceived blight. Due to these reasons, this option scores lower than Option H1.

Score = 1

Effectiveness for Area: This option scores low for the same reasons as Option H1.

Score = 1

Durability: This scores the same as Option H1 for the same reasons.

Score = 5

Construction Certainty: The excavation of the foreshore and replacement of clean import has the same constraints as identified for Option H1. Although screening of arisings is not required for this option, the construction of a suitable containment cell has significant constraints such as:

- suitable location, given the use as a sailing club and area for walkers;
- the depth to bedrock, which could result in a larger shallow construction; and
- consideration of the longer term longevity of any cell both with respect to design life of construction materials, the half life of the radium contamination and the potential for long term coastal erosion.

These concerns lower the construction certainty.

Score = 1

Coastal Processes Impact: This scores the same as Option H1 for the same reasons.

Score = 2

Additionally, this option has significant regulatory and other stakeholder implications which are considered in the following section.

Option H3 – Excavate foreshore, dispose off-site and replace foreshore with clean import

Essentially, this option is the same as Option H1. The significant difference relates to where screened arisings are placed. In this option, screening of foreshore arisings would still be required to segregate materials into activities that can be accepted by waste receivers, as there would be no intention to re-use any of the arisings. An alternative may be that off-site segregation of arisings could take place. Clean import would therefore be required.

The scoring of this option mirrors that of Option H1 for the same reasoning. This option also has potential limitations due to identification of disposal routes for potentially large volumes of different radium waste streams.

Option H4 – Reinforce armour stone and extend rock armour over all of the foreshore

Practicality: Reinforcing the armour stone and then extending rock armour across part or whole of the foreshore within the site area is considered reasonably practicable. The placement of rock/ stone from the landward edge of the foreshore seaward will itself provide a platform from which to undertake further rock armouring across part or all of the foreshore.

Score = 3

Effectiveness for Area: The rock armour will provide a barrier between any potential receptors and the existing foreshore material, thereby breaking any potential pathway, whilst through reinforcing current armouring, will limit exposure of contaminated infilled materials landward that have the potential, otherwise, to be exposed through coastal erosion. This provides for a high effectiveness.

Score = 4

Durability: Rock armouring can have a durable lifespan, especially with regular maintenance. The solution is only scored as having moderate durability as it is considered that with time, any remedial barrier solution within the tidal range will be exposed to storm events that with time could impact the integrity of the cover material to the foreshore.

Score = 3

Construction Certainty: The placement of rock armouring and its reinforcement is a well established process and can therefore be readily constructed.

Score = 4

Coastal Processes Impact: The placement of rock armouring over the foreshore area will have an effect on coastal processes. The headland area has the highest wave energy environment being considered and thus the most vulnerable foreshore. Although the extended armour apron would stabilise this foreshore and encourage some accretion, it is likely that it would have a groyne effect downdrift, and cause increased foreshore erosion in the slipway area.

Score = 3

Option H5 – Reinforce armour stone but with no extension over the foreshore

Similar scoring as Option H4 is applicable for practicality, durability and construction certainty with the following variances:

Effectiveness for Area: The reinforced armour stone along the landward edge of the foreshore will mitigate the potential longer term coastal erosion exposing contaminated infilling landward. However, the foreshore would still be subject to churn by wave action potentially mobilising radium contamination at depth resulting in continued potential pollutant linkages.

Score = 1

Coastal Processes Impact: Given there would be very little physical difference to the headland area it is envisaged that there will be very little impact to coastal processes. The increased wave energy reflecting off the 1:1 armour stone slope is likely to have contributed to the already low

foreshore level off the headland, and it is critical that the reinforcing of the existing armour stone is profiled to encourage more wave dissipation and less reflection, best achieved by reducing the armour gradient. With such design, this solution should encourage beach levels to rise.

Score = 4

Option H6 – Construct a marine barrier, e.g. groyne or offshore reef

Practicality: Groynes or offshore reefs are not as practicable to construct as onshore or foreshore works. Working within the marine environment poses significant difficulties. This results in a low score.

Score = 2

Effectiveness for Area: Marine barriers would not break any potential pathways to either current contamination identified on the foreshore or from infilled materials behind the current coastal protection measures, though accretion may be encouraged to raise the level of the beach acting as a barrier. Overall, this results in a relatively low score.

Score = 2

Durability: Durability of groynes or offshore reefs is considered to be broadly similar to that of extending rock armouring to the neap low tide level. The design of such features will provide a reasonable lifespan but by the very nature of existing within the marine environment and the limits on maintainability, the durability of such features will be impacted. This results in a medium score.

Score = 3

Construction Certainty: Work landward or within the intertidal zone has greater construction certainty. When working within the marine environment, the construction certainty will not be as high, although construction processes will ensure a high degree of quality.

Score = 3

Coastal Processes Impact: By their very nature, marine barriers will have an impact on coastal processes which will need further detailed monitoring of current conditions and modelling of proposed conditions to qualify actual impacts. Although the impact would also be significant on boat users and other receptors, a correctly designed reef, breakwater or groyne, possibly incorporating imported beach "seeding" to the newly sheltered foreshore, would have a major positive effect on coastal processes, encouraging beach accretion to all 4 areas. It is worth noting this would significantly increase the amenity value of the foreshore.

Score = 5

Option H7 – Combination of Options (H7 Series)

There are a number of possible combinations of Options H1 to H6. These can be broadly considered as follows:

- Foreshore excavation (H1 to H3) with reinforcing armour stone only (H5) – provided as options H7A, H7C and H7E;
- Foreshore excavation (H1 to H3) with marine barrier (H6) – provided as options H7B, H7D and H7F;

- Reinforce armour stone and extend rock armour over part or all of the beach (H4) with marine barrier (H6) – provided as options H7G;
- Reinforce rock armour only (H5) with marine barrier (H6) – provided as options H7H;
- Foreshore excavation (H1 to H3), with reinforcing armour stone only (H5) and installation of marine barrier (H6) – provided as options H7I to H7K.

The remaining possible combinations of excavation with extended rock armouring over the foreshore with or without marine barriers are not considered further as these will not provide any further benefit over and above the single option of rock armour reinforcing and extension.

The only stand alone option is Option H4 which can work in isolation, although Option H6 could potentially increase beach levels enough to protect the existing armour stone slope from any further erosion.

The scoring of each of the combination of options relates to reviewing the scores of the individual options, identified above, together with consideration of the combined effect. Scoring the combination of options as shown in Table 1B indicates H7K (excavation of foreshore option, reinforcing rock armouring and marine barrier installation) as the highest scoring option, though many of the combinations score very closely.

Area S (Slipway)

Option S1 - Excavate foreshore, remove radioactive material and replace

Practicality: The foreshore of Area S is either covered or mostly covered during high tides (spring and neap respectively). During neap low tides the approximate lower 10m of the foreshore remains covered within the site area. Only during spring low tides is the foreshore completely exposed. This places a significant constraint on timings of excavation although to a lesser extent than Area H. The excavation and on-site screening of all foreshore materials from Area S is considered less practical than other excavation options due to the physical area required to undertake the screening, the stockpiling of segregated materials and the potential for either the site to become constrained by materials at surface or progression being so slow so as to decrease the overall efficiency. This option also has potential limitations due to identification of disposal routes for different radium waste streams. Validation may be a more difficult process compared to direct replacement.

Score = 2

Effectiveness for Area: Excavation and removal of the contamination on the foreshore will be a reasonably effective means of breaking the contaminant pathway but is dependent upon the resolution of the equipment to ensure all required contamination has been removed. To be fully effective the removal of contamination below the slipways would be required.

Score = 4

Durability: The removal of contaminants will ensure a reasonably durable solution removing the contaminant from the potential pollutant linkage. However, this option is limited to the efficiency of the equipment being used to segregate materials for re-use and for disposal. This does not score as well as for options where clean materials are imported.

Score = 4

Construction Certainty: As for excavation of Area H, ensuring excavation sides do not slump and the base of excavation does not over-excavate into uncontaminated underlying sands together with likelihood of a very variable rockhead profile gives considerable uncertainty as to excavation and waste quantities, which further exasperates the construction certainty of this option. Furthermore, ensuring all radioactive material has been removed from the excavated foreshore prior to replacement poses difficulties with respect to equipment resolution moisture content and, ultimately, throughput. This would have a direct impact on programme. The replacement of the foreshore materials would need careful consideration to ensure replaced materials are not simply washed away with the daily tidal processes.

Score = 2

Coastal Processes Impact: The impact to any coastal processes is considered relatively minimal. Any replacement of slipways would require careful consideration. Apart from the duration of the works, in broad terms the foreshore will be very similar in condition to prior to commencement. There is a slight risk that the disturbance will mobilise previously stable sediment, and encourage further erosion, but this is much less than for Area H.

Score = 3

Option S2 - Excavate foreshore and remove radioactive material to site containment area, with clean import

For the purposes of excavation and replacement, the same principles as Option S1 apply. However, there are variances which are described below.

Practicality: The screening process required in Option S1 would not be required for Option S2. However, a major drawback to this option is the requirement for locating an area that would be suitable for a containment cell and constructing the containment cell for an appropriate design life. This may necessitate the demolition of current buildings and carries with it the potential for long-term perceived blight. Due to these reasons, this option scores lower than Option H1.

Score = 1

Effectiveness for Area: This option scores high for the same reasons as Option S1.

Score = 5

Durability: This scores the same as Option S1 for the same reasons.

Score = 5

Construction Certainty: The excavation of the foreshore and replacement of clean import has the same constraints as identified for Option H1. Although screening of arisings is not required for this option, the construction of a suitable containment cell has significant constraints as identified previously under Option H2.

These concerns lower the construction certainty.

Score = 1

Coastal Processes Impact: This scores the same as Option S1 for the same reasons.

Score = 3

Additionally, this option has significant regulatory and other stakeholder implications which are considered in the following section.

Option S3 – Excavate foreshore, dispose off-site and replace with clean import

Essentially, this option is the same as Option S1. The significant difference relates to where screened arisings are placed. In this option, screening of foreshore arisings would still be required to segregate materials into activities that can be accepted by waste receivers, as there would be no intention to re-use any of the arisings. An alternative may be that off-site segregation of arisings could take place. Clean import would therefore be required.

The scoring of this option mirrors that of Option S1 for the same reasoning. Additionally this option also has potential limitations due to identification of disposal routes for potentially large volumes of differing radium waste streams.

Option S4 – Remove radium to Criterion 1 and cover foreshore area with concrete

Practicality: As for Options S1 to S3, the tidal levels influence the practicality of constructing a mass concrete area across the foreshore. There are a number of structures already present on the foreshore, namely the jetty and slipways, which could be readily tied into and form defined edges with which to work to. The north-eastern extent of Area S would be more difficult to define, though the outcrop of rock would make a possible working boundary. Other than working to spring tides, the eastern extent of Area S will be covered and will require more complex working methodologies. Additionally, the concrete may require extending vertically downward at the eastern and north-eastern extent to mitigate the risk of foreshore materials beneath the concrete being washed out.

Score = 3

Effectiveness for Area: The effective encapsulation of contaminants beneath the concrete will sever any potential pollutant linkage. This would suggest an effective remediation option.

Score = 4

Durability: The design of any concrete cover will allow reasonable design life but will be subject to continued maintenance to ensure there are no defects.

Score = 3

Construction Certainty: The construction of the concrete cover over the foreshore will be reasonably straight forward. What is potentially more difficult is any vertical component that may be required along the eastern and north-eastern extent of Area S boundary where excavation work will be completed in either saturated or near saturated ground conditions to depths yet to be determined.

Score = 4

Coastal Processes Impact: There is likely to be a significant impact on coastal processes by the installation of a concrete cover, as the longshore drift of sediment would be fundamentally interrupted and wave energy dissipation compromised. This could increase beach erosion both downdrift in areas BS and BN and immediately seaward due to increased wave energy levels.

Score = 1

Option S5 – Remove radium to Criterion 1 , construct replacement slipway and armour beach

For the purposes of scoring, there is little difference between this option and Option S4 as both comprise the installation of a cover system across the foreshore within Area S. The rock armour cover is more straightforward to construct than concrete as it is less susceptible to tidal conditions and therefore scores slightly higher on practicality at 4. There is also less impact on the coastal processes as the armour stone would dissipate wave energy than Option S4 and therefore scores higher for coastal processes impact at 2.

Option S6 – Construct a marine barrier, e.g. groyne or offshore reef

A marine barrier that would be effective for Area S would, in all likelihood, form part of the same marine barrier designed for Option H6. Therefore, the same scoring and justification is applied to this option as is described above for Option H6.

Option S7 – Combination of Options (S7 Series)

The majority of the options outlined above comprise either beach removal or cover and are therefore considered mutually exclusive, i.e. there would be little justification for removal of radioactive material and then covering the beach. Viable combinations of options therefore comprise cover systems in combination with marine barriers:

- Cover foreshore with concrete (large slipway) and construct a marine barrier – Option S7A; or
- Build replacement slipway and cover or rock armour foreshore and construct a marine barrier – Option S7B.

The scoring of each of the combination of options relates to reviewing the scores of the individual options, identified above, together with consideration of the combined effect.

Area BS (Boat Park Bay South)

Option BS1 – Monitor and remove radioactive material

Practicality: Similar work has been on-going over the last 2 years and is reasonably practicable being flexible to tide levels.

Score = 4

Effectiveness for Area: Area BS would clearly benefit from continued monitoring and removal of radioactive material identified. However, the degree of certainty by which pollutant linkages has been severed is not as great as other options. Ashy infill, landward, immediately beyond the foreshore and installed coastal protection measures is present. Coastal erosion could mobilise landward material and would not be effectively addressed by this option alone.

Score = 3

Durability: The removal of contamination through monitoring will provide a durable solution in the longer term, but scores lower than other options due to it not being an immediate solution.

Score = 3

Construction Certainty: As there is no intrusive work other than the localised removal of radium contamination, this option has a very high construction certainty.

Score = 5

Coastal Processes Impact: There would be no variance to the current coastal conditions by employing this option resulting in a very low impact on a low wave energy environment.

Score = 3

Option BS2 - Excavate upper sandy foreshore (strand), remove radioactive material and replace

Practicality: The localised strand is exposed from neap high tides and below making the excavation of the strand achievable within the constraints of tidal levels. Excavation could be readily undertaken though it would be best programmed to coincide with low tides. In terms of practicality, this option scores higher than the Area S excavation option as it is less affected by tidal cover although there will be some need to protect the works.

Score = 4

Effectiveness for Area: The removal of one of the key areas of contamination will significantly improve the quality of the foreshore within Area BS. However, this is partially off-set by the ashy infill located behind the current coastal defences that could potentially remobilise contamination in the future through storm events. The potential for remobilisation is considered less than that for Area H.

Score = 2

Durability: The removal of contaminants will ensure a reasonably durable solution removing the contaminant from the potential pollutant linkage. However, this option is limited to the efficiency of the equipment being used to segregate materials for re-use and for disposal. This does not score as well as for options where clean materials are imported.

Score = 4

Construction Certainty: Given the area of foreshore exposure at low tide and the generally steepening of the foreshore to the strand, excavation of this area is considered feasible. Given the length of the foreshore to be excavated, some mitigation measures would be required to minimise risks of excavation collapse. There is also uncertainty in excavation quantities due to a very variable rockhead profile. This option therefore scores moderately.

Score = 5

Coastal Processes Impact: The foreshore will only be affected during the construction works. On completion, the foreshore will broadly have the same profile as before works commenced resulting in a very low impact on coastal processes, which are at low energy levels in this area.

Score = 3

Option BS3 - Excavate upper sandy foreshore (strand) and remove radioactive material to site containment area

For the purposes of scoring, this option is equivalent to Option BS2, with the exception of practicality and construction certainty, i.e. where the final disposal point of recovered radium contamination is located.

Practicality: As for other areas involving excavation to an on-site containment area, defining an area that would be suitable for a containment cell and constructing the containment cell for an appropriate design life would be major drawbacks. This may necessitate the demolition of

current buildings and carries with it the potential for long-term perceived blight and consequently has a low score.

Score = 1

Construction Certainty: As noted under Option H2 above, there are a number of uncertainties with construction of a containment cell that detract from this option, hence a low score.

Score = 1

Option BS4 - Excavate upper sandy foreshore (strand) and dispose off-site, with clean import

This option in principle the same as Option BS2. The significant difference relates to where screened arisings are placed, i.e. off site rather than replace. Screening of foreshore arisings would still be required to segregate materials into activities that can be accepted by waste receivers, as there would be no intention to re-use any of the arisings. An alternative may be that off-site segregation of arisings could take place. Clean import would therefore be required.

The scoring of this option mirrors that of Option S1 for the same reasoning.

Option BS5 – Improve current rock armour

Practicality: Any improvements to the rock armour can be readily achieved. The spring high tides reach the base of the embankment against which the coastal defences are currently installed. Therefore, this is a highly practical solution.

Score = 5

Effectiveness for Area: In isolation, improving the coastal defences will not negate the presence of radioactive contamination on the beach and therefore must be considered in combination with another option (see Option BS7 series below). However, it will mitigate against the erosion of ashy infill behind the current coastal defences.

Score = 1

Durability: The design of any improvements to the coastal defences will allow reasonable design life but will be subject to continued but minimal maintenance. The tidal energy in this area is generally low so the durability of armouring is expected to be greater than for Areas H and S.

Score = 4

Construction Certainty: There is a high degree of construction certainty involved with the improvement of coastal defences.

Score = 4

Coastal Processes Impact: Improving the coastal defences above the spring high tide level will improve resistance to the coastal processes in this area during storm events.

Score = 4

Option BS6 – Remove radium to Criterion 1, improve and extend rock armouring across sandy foreshore (strand)

Practicality: Extending the rock armour across the strand (or possibly the whole of the beach within the site area if considered necessary) is considered practicable. The placement of

rock/stone from the landward edge of the foreshore seaward, will itself provide a platform from which to undertake further rock armour cover across part or all of the foreshore. The tidal constraints are not as significant as Area H and S resulting in a relatively high score.

Score = 4

Effectiveness for Area: The rock armour across the foreshore will provide a barrier between any potential receptors and underlying contamination, thereby breaking any potential pathway. By reinforcing current armouring, this will limit exposure of contaminated infilled materials landward that have the potential, otherwise, to be exposed through coastal erosion. This provides for a high effectiveness.

Score = 4

Durability: Rock armouring can have a durable lifespan, especially with regular maintenance. The solution is scored as having a high durability as wave energy is less in this area than those to the south.

Score = 4

Construction Certainty: The placement of rock armouring and its reinforcement is a well established process and can therefore be readily constructed, though some consideration to protecting the works will be required to ensure they are not damaged during construction.

Score = 4

Coastal Processes Impact: The placement of rock armouring over the foreshore area will have an effect on coastal processes by dissipating wave energy before it reaches the coastal defence However, it is noted that Area BS is one of the lower energy environments and the effects of foreshore rock armouring would be minimised.

Score = 5

It is also noted that should marine barriers be installed for Areas H and S, this in turn would have a positive impact on the foreshore environment in terms of beach cover.

Option BS7 – Combination of Options (BS7 Series)

The combination of options within Area BS generally comprises either excavation/cover systems combinations (the latter either preventing further erosion of the landward face or covering of the wider beach) or cover/ monitoring systems. These comprise:

- Excavation of strand (BS2 to BS4) and on-going monitoring (BS1), given as Options BS7A to BS7C;
- Excavation of strand (BS2 to BS4) and reinforcing/replacing rock armour (BS5), given as Options BS7D to BS7F;
- Reinforcing/replacing rock armour (BS5) and on-going monitoring (BS1), given as Option BS7G;

There would be no combination of excavation followed by covering as the excavation work will have already removed the contamination.

By scoring the attributes of combination of options as shown in Table 1B, the highest scoring option is Option BS7G (reinforcing/replacing rock armour with on-going monitoring) which is

less disruptive to the foreshore than the next highest Options BS6D to BS7F (excavation of strand, reinforcing/ replacing coastal defences).

Area BN (Boat Park Bay North)

The scoring for Area BN options is identical to that of Area BS. The physical difference between the two areas relates to the activity associated with ashy fill behind the current coastal protection measures. The wave energy environment in Area BN is even lower than that in Area BS, with only a single row of armour stone boulders currently present.

As noted for Area BS should marine barriers be installed for Areas H and S, this in turn would have a positive impact on the foreshore environment in terms of beach cover.

Area BNZ (Boat Park Bay North Zone 1)

Option BNZ1 – Monitor and remove radioactive material

The same scoring applies to this option as for the wider Area BN and BS options.

Option BNZ2 – Excavate localised landward ashy infill to on-site containment cell, replace with clean import

Practicality: Excavation of the localised ashy infill is readily practicable as this is located at or above the mean high water spring. However, identifying the area for and subsequently constructing a containment cell proves very impractical given the variable depth to shallow rockhead and the physical constraints on site, for example, current structures. Subsequently a low score is given.

Score = 1

Effectiveness for Area: The removal of one of the key areas of contamination will significantly improve the quality of the foreshore within Area BN. Therefore, this scores very highly.

Score = 5

Durability: The removal of contaminants makes this a durable option in respect of potential for repopulating the contamination within the foreshore. However, long term coastal erosion, the longevity of any containment cell coupled with the half life of the radium contaminant of concern, results in a lowered score.

Score = 3

Construction Certainty: This option comprises landward works which have a much higher construction certainty than foreshore works.

Score = 5

Coastal Processes Impact: The foreshore will only be affected during the construction works. On completion, the foreshore will broadly have the same profile as before works commenced resulting in a low impact on coastal processes, which are at low energy levels in this area.

Score = 3

Option BNZ3 - Excavate localised landward ashy infill off-site, replace with clean import

This option has the same scores as Option BNZ2 with the exception of practicality which scores a relatively higher 4 due to the arisings requiring off-site disposal rather than on-site containment.

Option BNZ4 – Install rock armour

This option scores the same as for the wider area BN5 rock armouring with the exception of effectiveness for area, which is scored much higher as a result of landward contaminants being isolated from the foreshore. The resultant score for effectiveness is 5.

Combination of Options (BNZ5 Series)

The combination of options within Area BNZ generally comprises excavation with rock armouring. These comprise:

- Excavation of landward infill to site containment cell and install rock armour, given as Option BNZ5A; or
- Excavation of landward infill for off-site disposal and install rock armour, given as Option BNZ5B.

By scoring the attributes of combination of options as shown in Table 1B, the highest scoring option is Option BNZ5B.

Dalgety Bay Management Strategy Options - Attribute Table 1A

See Drawing 23218/SHR/392 for Area Locations

			Score	**Attribute** *Min (1)* *Max (5)*	***Practicality*** *Very difficult to implement* *Straightforward*	***Effectiveness for Area*** *SPLs not addressed* *SPLs fully addressed*	***Durability*** *Not durable* *Very durable*	***Construction Certainty*** *Very low confidence* *Very high confidence*	***Coastal Processes Impact*** *High negative impact* *High positive impact*	**Total Table 1A Score**	**Can the option work in isolation?** **(if so carry forward)**
Remediation Area	**Option Identifier**	**Description**									
Area H (Headland)	H1	Excavate, screen, replace foreshore			2	1	4	2	2	11	×
Area H (Headland)	H2	Excavate to containment cell, import clean			1	1	5	1	2	10	×
Area H (Headland)	H3	Excavate, screen, off-site disposal, import clean			2	1	5	2	2	12	×
Area H (Headland)	H4	Reinforce/replacement of current armour stone,extend over foreshore			3	4	3	4	3	17	✓
Area H (Headland)	H5	Structurally reinforce current armour stone			4	1	3	4	4	16	×
Area H (Headland)	H6	Marine barrier construction- e.g. groyne, offshore reef			2	2	3	3	5	15	×
Combination of options are shown on Table 1B											
Area S (Slipways)	S1	Excavate, screen, replace foreshore			2	4	4	2	3	15	✓
Area S (Slipways)	S2	Excavate to containment cell, import clean			1	5	5	1	3	15	✓
Area S (Slipways)	S3	Excavate, screen, off-site disposal, import clean			3	5	5	2	3	18	✓
Area S (Slipways)	S4	Removal of radium to meet Criterion 1, concrete over foreshore			3	4	3	4	1	15	✓
Area S (Slipways)	S5	Removal of radium to meet Criterion 1, build new slipway and cover foreshore (armour)			4	4	3	4	2	17	✓
Area S (Slipways)	S6	Marine barrier construction- e.g. groyne, offshore reef			2	2	3	3	5	15	×
Combination of options are shown on Table 1B											
Area BS (Boatyard South)	BS1	Monitor and remove radium contamination			4	3	3	5	3	18	✓
Area BS (Boatyard South)	BS2	Excavate upper sandy foreshore (strand), screen and replace foreshore			4	2	4	3	3	16	×
Area BS (Boatyard South)	BS3	Excavate upper sandy foreshore (strand) to containment cell, import clean			1	2	5	1	3	12	×
Area BS (Boatyard South)	BS4	Excavate upper sandy foreshore (strand) for off-site disposal, import clean			4	3	5	3	3	18	×
Area BS (Boatyard South)	BS5	Reinforce/replace current rock armouring			5	1	4	4	4	18	×
Area BS (Boatyard South)	BS6	Removal of radium to meet Criterion 1, reinforce/replace and extend current rock armour to cover the upper sandy foreshore			4	4	4	4	5	21	✓
Combination of options are shown on Table 1B											
Area BN (Boatyard North)	BN1	Monitor and remove radium contamination			4	3	3	5	3	18	✓
Area BN (Boatyard North)	BN2	Excavate upper sandy foreshore (strand), screen and replace foreshore			4	2	5	3	3	17	×
Area BN (Boatyard North)	BN3	Excavate upper sandy foreshore (strand) to containment cell, import clean			1	2	5	1	3	12	×
Area BN (Boatyard North)	BN4	Excavate upper sandy foreshore (strand) for off-site disposal, import clean			5	2	5	3	3	18	×
Area BN (Boatyard North)	BN5	Reinforce/replace current rock armouring			5	1	4	4	4	18	×
Area BN (Boatyard North)	BN6	Removal of radium to meet Criterion 1, reinforce/replace and extend current rock armour to cover the upper sandy foreshore			4	4	4	4	5	21	✓
Combination of options are shown on Table 1B											
Area BN-Z1 (Boatyard North Zone 1)	BNZ1	Monitor and remove radium contamination on foreshore			4	3	3	5	3	18	✓
Area BN-Z1 (Boatyard North Zone 1)	BNZ2	Excavate localised landward ashy infill to on-site containment area, replace with clean import			1	5	3	5	3	17	✓
Area BN-Z1 (Boatyard North Zone 1)	BNZ3	Excavate localised ashy infill for off-site disposal, replace with clean import			4	5	3	5	3	20	✓
Area BN-Z1 (Boatyard North Zone 1)	BNZ4	Install rock armour			4	5	4	4	4	21	✓
Combination of options are shown on Table 1B											

Dalgety Bay Management Strategy Options - Attribute Table 1B

See Drawing 23218/SHR/392 for Area Locations

Remediation Area	Option Identifier	Description	Score / Attribute (Min (1) Max (5))	***Practicality*** *Very difficult to implement Straightforward*	***Effectiveness for Area*** *SPLs not addressed SPLs fully addressed*	***Durability*** *Not durable Very durable*	***Construction Certainty*** *Very low confidence Very high confidence*	***Coastal Processes Impact*** *High negative impact High positive impact*	**Total Table 1B Score**	**Can these combinatins work? (if so carry forward)**
Area H (Headland)	H7A	Excavate, screen, replace foreshore and reinforce armour stone(H1+H5)		2	4	4	2	4	16	✓
Area H (Headland)	H7B	Excavate, screen, replace foreshore and construct marine barrier (H1+H6)		2	2	4	2	4	14	×
Area H (Headland)	H7C	Excavate to containment cell, import celan and reinforce armour stone (H2+H5)		1	5	4	1	4	15	✓
Area H (Headland)	H7D	Excavate to containment cell, import clean and construct marine barrier (H2+H6)		1	2	4	2	4	13	×
Area H (Headland)	H7E	Excavate, screen, off-site disposal, import clean and reinforce armouring stone (H3+H5)		2	5	4	2	4	17	✓
Area H (Headland)	H7F	Excavate, screen, off-site disposal, import clean and construct marine barrier (H3+H6)		2	2	4	2	4	14	×
Area H (Headland)	H7G	Reinforce/replace current armour stone, extend over foreshore and construct marine barrier (H4+H6)		3	4	3	2	4	16	✓
Area H (Headland)	H7H	Reinforce current armour stone and construct marine barrier (H5+H6)		3	2	3	2	5	15	×
Area H (Headland)	H7I	Excavate, screen, replace foreshore, reinforce armouring stone and construct marine barrier (H1+H5+H6)		2	4	4	2	5	17	✓
Area H (Headland)	H7J	Excavate to site containment cell, import clean, reinforce armouring stone and constrcut marine barrier (H2+H5+H6)		1	5	4	2	5	17	✓
Area H (Headland)	H7K	Excavate, screen, off-site disposal, import clean, reinforce armouring stone and constrcut marine barrier (H3+H5+H6)		2	5	5	2	5	19	✓
Area S (Slipways)	S7A	Removal of radium to meet Criterion 1, concrete over foreshore and construct marine barrier (S4+S6)		2	5	4	3	2	16	✓
Area S (Slipways)	S7B	Removal of radium to meet Criterion 1, build new slipway, cover foreshore (armour) and construct marine barrier (S5+S6)		2	5	4	3	2	16	✓
Area BS (Boatyard South)	BS7A	Excavation of strand, screen, replace and on-going monitoring (BS2+BS1)		4	2	3	3	3	15	✓
Area BS (Boatyard South)	BS7B	Excavation of strand to containment cell, import clean and on-going monitoring (BS3+ BS1)		4	2	3	3	3	15	✓
Area BS (Boatyard South)	BS7C	Excavation of strand, screen, off-site disposal, import clean and on-going monitoring (BS4+BS1)		4	2	3	3	3	15	✓
Area BS (Boatyard South)	BS7D	Excavation of strand, screen, replace and reinforce/replace current rock armouring (BS2+BS5)		4	4	3	3	3	17	✓
Area BS (Boatyard South)	BS7E	Excavation of strand to containment cell, import clean and reinforce/replace current rock armouring (BS3+BS5)		4	4	4	3	3	18	✓
Area BS (Boatyard South)	BS7F	Excavation of strand, screen, off-site disposal, import clean and reinforce/replace current rock armouring (BS4+BS5)		4	4	4	3	3	18	✓
Area BS (Boatyard South)	BS7G	Reinforce/replace current rock armouring and on-going monitoring (BS5+BS1)		5	4	3	4	4	20	✓
Area BN (Boatyard North)	BN7A	Excavation of strand, screen, replace and on-going monitoring (BN2+BN1)		5	2	3	3	3	16	✓
Area BN (Boatyard North)	BN7B	Excavation of strand to containment cell, import clean and on-going monitoring (BN3+ BN1)		4	2	3	3	3	15	✓
Area BN (Boatyard North)	BN7C	Excavation of strand, screen, off-site disposal, import clean and on-going monitoring (BN4+BN1)		4	2	3	3	3	15	✓
Area BN (Boatyard North)	BN7D	Excavation of strand, screen, replace and reinforce/replace current rock armouring (BN2+BN5)		4	4	3	3	3	17	✓
Area BN (Boatyard North)	BN7E	Excavation of strand to containment cell, import clean and reinforce/replace current rock armouring (BN3+BN5)		4	4	4	3	3	18	✓
Area BN (Boatyard North)	BN7F	Excavation of strand, screen, off-site disposal, import clean and reinforce/replace current rock armouring (BN4+BN5)		4	4	4	3	3	18	✓
Area BN (Boatyard North)	BN7G	Reinforce/replace current rock armouring and on-going monitoring (BN5+BN1)		5	4	3	4	4	20	✓
Area BN-Z1 (Boatyard North Zone 1)	BNZ5A	Excavate localised landward ashy infill to on-site containment area, replace with clean import and install rock armour		4	4	4	5	4	21	✓
Area BN-Z1 (Boatyard North Zone 1)	BNZ5B	Excavate localised ashy infill for off-site disposal, replace with clean import and install rock armour		5	4	4	5	4	22	✓

Annex C
Tier 2: Attribute Table 2 and Tier 2 Attribute Scoring Assessments

16 Pages

Tier 2 Attribute Scoring Assessment

Area H (Headland)

Option H7I – Excavation of foreshore, remove radioactive material, replace and reinforce current armouring stone and marine barrier installation.

Works Impact: Excavation of the foreshore and the removal of radium contamination will require a reasonable sized area to house equipment, plant and offices or temporary storage for draining down of wet materials and will likely result in disruption to any landward activities for periods of time. Additionally, the import of rock for armouring, if undertaken by roadway, would cause impact to the local residential community. However, the import of materials to form a marine barrier is likely to be less intrusive. Overall, this option has a relatively low score.

Score = 2

Environmental Effects: Excavation of the foreshore may have effects on the local environment and has the potential to interfere with migratory birds depending on the season undertaken. There could be impacts to the marine environment where a barrier, such as an off-shore breakwater, was to be installed. Additionally, the placement of a barrier could provide increased accretion which, although good for raising beach levels, could have negative effect on wider biodiversity.

Score = 2

Processes and Authorisations: The excavation of the foreshore would require Forth Port Authority agreement and any work undertaken on the rock armouring would need to done in consultation with Fife Council. It is likely an EIA would also be required which may require a Habitats Regulations Assessment. Permits are likely to be required for any landward screening of foreshore arisings. Additionally, consents would be required to undertake any marine work with wide ranging consultation. Given the Ramsar designation of the site, additional authorisations may well be required. However, these requirements can be planned for.

Score = 2

Stakeholder Support: Undertaking excavation across the foreshore will also require the cooperation of the landowners, namely Moray Estates, and for the foreshore and rock armour, the land users. There is currently uncertainty regarding Moray Estates view with respect to foreshore excavation works, but given the beneficial outcome, it has been assumed for the purposes of this assessment that Moray Estates will not contest such works being undertaken. The number of people accessing the headland is very small, partly due to the limited access, a function of the relatively steeply shelving foreshore and tidal levels, together with the gravel and cobble sized surface and rocky outcrop across the foreshore. The landward land user cooperation is considered favourable for the reinforcing of the current rock armour. For any off-shore marine installations, these may in fact prove beneficial to boat users in providing calmer waters for entry either into the bay or for boat removal/launching operations from the slipways. However, there could also be objections to further off-shore 'obstructions'.

Score = 2

Sustainability: Excavation of the foreshore and screening for radioactive material will result in some loss of material but this is considered to be minimal compared to the large volume of excavated material that will be replaced back into void. Therefore, this is considered a

reasonably sustainable approach. If, however, excavated materials were not replaced in the foreshore void, i.e. removed off-site, this would rank poorly for sustainability. Rock armouring reinforcement and marine barrier installation would require transporting large boulder sized rock to the site, this having an associated carbon footprint. Overall, this provides for a reasonable sustainability outcome.

Score = 3

Option H7J - Excavation of foreshore to site containment area, replace with clean import and reinforce current armouring stone and marine barrier installation

This option scores the same for each attribute as Option H7I, above, with similar justifications with the notable exceptions of:

Processes and Authorisations: In addition to the authorisations required as noted above, it is considered very complex and difficult to secure the necessary licensing for an on-site containment facility in which to provide long-term landfilling of radium contamination. Subsequently, this option scores very low.

Score = 1

Stakeholder Support: It is considered that landfilling foreshore arisings landward will not be acceptable to stakeholders and there will be a perception of blight.

Score = 1

It is recognised that screening may not necessarily be required for arisings being placed directly to a containment facility.

Option H7K - Excavation of foreshore, dispose off-site, replace with clean import, reinforce current armouring stone and marine barrier installation.

This option scores the same for each attribute as Option H7I, above, with similar justifications with the notable exception of:

Sustainability: The off-site disposal of contaminated arisings and import of clean infill has a major carbon footprint and would require the movement of haulage wagons through the local residential area as well as having a potentially significant cost implication (considered further at Stage 4). The marine barrier installation, however, potentially has a much smaller footprint as does current armouring reinforcement where materials could potentially be barged in causing less environmental and social impact. Overall, on the basis of environmental, social and economic reasoning, this option scores poorly for sustainability.

Score = 1

Option H4 – Remove radium to Criterion 1, reinforce armour stone and extend rock armour over all of the foreshore

Works Impact: Undertaking reinforcing works along the headland is considered to be of relatively low amenity impact. Footpaths and activities at the Sailing Club (onshore and offshore) would not be significantly affected. Overall, this scores relatively highly.

Score = 4

Environmental Effects: Given the number of natural rock outcrops and boulder and cobble coverage across the intertidal zone, the relative effects in biodiversity are not considered high or low, giving a moderate score.

Score = 3

Processes and Authorisations: Amongst other authorisations, works undertaken to reinforce the armour stone will need to be completed in consultation with Fife Council and any works below the mean high water spring will require Forth Ports Authorisation. Additional authorisations are anticipated given the Ramsar designation.

Score = 3

Stakeholder Support: As the amenity impact is anticipated to be much lower than the previous identified options, resultantly stakeholder support is considered to be higher. Furthermore, if materials for armouring are delivered by marine transport there will be even less impact. This area of the foreshore is also not frequented by the public as much as the beaches within the bay. However, work would be undertaken across Moray Estates landholding and their acceptance of such a proposal has not yet been determined. Overall, this scores moderately.

Score = 3

Sustainability: A higher score is given for sustainability on the assumption that armouring materials can be delivered by a marine route. Unwanted materials from, for example, blasting operations can provide a sustainable resource. With minimal social impact, a lower carbon footprint by marine transport and a sustainable resource, overall, this option scores relatively well.

Score = 4

Option H7A – Excavation of foreshore, screen and replace and reinforce current armouring

This option scores the same as Option H7I due to their similarities. The only variance relates to the installation of a marine barrier which is not considered to overtly effect the overall scoring.

Option H7C – Excavation of foreshore to site containment area, replace with clean import and reinforce current armouring

This option scores the same as Option H7J due to their similarities. The only variance relates to the installation of a marine barrier which is not considered to overtly effect the overall scoring.

Option H7G – Remove radium to Criterion 1, reinforce armour stone, extend over foreshore and installation of a marine barrier

This option scores the same as Option H4, above, due to their similarities with the exception of the Processes and Authorisations attribute which scores slight lower due to the additional marine authorisations required to install a marine barrier. This attribute scores a moderate 3.

Option H7E – Excavation of foreshore, dispose off-site, replace with clean import and reinforce current armouring

This option scores the same as Option H7K due to their similarities. The only variance relates to the installation of a marine barrier which is not considered to overtly effect the overall scoring.

Area S (Slipway)

Option S1 – Excavate foreshore, remove radioactive material and replace

Works Impact: The excavation of the foreshore is considered to have a relatively high amenity impact given the higher frequency of users on this area of the beach. Users predominantly comprise both walkers and those participating in sailing activities. Additionally, large areas of the Sailing Club grounds may be required to undertake screening of arisings or temporary

storage for draining down of wet materials as well as storage of plant and equipment necessary to undertake the excavation works. Consequently, excavation of the foreshore scores low.

Score = 2

Environmental Effects: Excavation of the foreshore may have effects on the local environment and has the potential to interfere with migratory birds depending on the season undertaken.

Score = 2

Processes and Authorisations: Given the location of the excavation, Forth Port Authority agreement would be required. Permits are likely to be required for any landward screening of foreshore arisings. It is likely an EIA would also be required which may require a Habitats Regulations Assessment. Given the Ramsar designation of the site, additional authorisations may well be required.

Score = 2

Stakeholder Support: Support and cooperation will be required of the landowners, Moray Estates, and for the foreshore, the beach users. As noted before, it has been assumed for the purposes of this assessment that Moray Estates will not contest such works being undertaken given the beneficial outcome. Given the higher public usage in this area, and across the wider Sailing Club, stakeholder support could be more problematic. Additionally, screening of materials at site and stockpiling of both re-use and waste materials may not be well received compared to direct removal off-site.

Score = 2

Sustainability: Reuse of arisings, once screened to remove unacceptable levels of activity, will provide a reasonably sustainable approach with minimal need for import of materials, reducing wagon movements and having less of an impact on the local residential community. Overall, this option scores reasonably high.

Score = 4

Option S3 – Excavate foreshore, dispose off-site and replace foreshore with clean import

This option, being very similar to Option S1, scores the same for the various attributes with the exception of stakeholder support and sustainability.

Stakeholder Support: This is considered a slightly higher scoring than the S1, though only marginally. The justification for this relates to the lack of significant screening being carried out on site and the potential concerns the screening process may have with local stakeholders,

Score = 3

Sustainability: In this case, the transport of haulage wagons to and from the site for disposal and import of materials has a higher carbon footprint and a higher social impact to the local residential community compared with Option S1. Overall, this option scores lower.

Score = 2

Option S5 – Remove radium to Criterion 1, build replacement slipway and rock armour foreshore

Works Impact: As noted under other options above, use of Area S foreshore is frequent by the general public and, therefore, any work will cause impacts to amenity receptors.

Score = 2

Environmental Effects: There is the potential for environmental impacts from the slipway and rock armouring activities. The three slipway/jetty structures already installed across Area S only contribute to a small area, indicating the potential for a higher environmental impact. Additionally, activities may have the potential to interfere with migratory birds depending on the season undertaken.

Score = 2

Processes and Authorisations: Given the rock armouring would extend below the mean high tide spring, the Forth Port Authority agreement would be required. It is likely an EIA would also be required which may require a Habitats Regulations Assessment. Given the Ramsar designation of the site, additional authorisations may well be required. Depending on the designation of the works, Fife Council may also need to be consulted.

Score = 3

Stakeholder Support: As noted earlier, stakeholder support could be more difficult to obtain in this area given the relative use of the foreshore. Moray Estates, as landowners, would also need to give approval.

Score = 3

Sustainability: A higher score is given for sustainability on the assumption that armouring materials can be delivered by a marine route. Unwanted materials from, for example, blasting operations can provide a sustainable resource. With minimal social impact, a lower carbon footprint by marine transport and a sustainable resource, overall, this option scores relatively well.

Score = 4

Option S2 – Excavate foreshore and remove to containment area with clean import

This option, being very similar to Option S1, scores the same for the various attributes with the exception of:

Processes and Authorisations: In addition to the authorisations required as noted above, it is considered very complex and difficult to secure the necessary licensing for an on-site containment facility in which to provide long-term landfilling of radium contamination. Subsequently, this option scores very low.

Score = 1

Stakeholder Support: It is considered that landfilling foreshore arisings landward will not be acceptable to stakeholders and there will be a perception of blight.

Score = 1

Option S7A – Remove radium to Criterion 1, cover foreshore with concrete (large slipway) and construct marine barrier

Works Impact: As noted under other options above, use of Area S foreshore is frequent by the general public and, therefore, any work will cause impacts to amenity receptors. The construction of a marine barrier may have a lower amenity receptor impact, especially if construction material delivery is all via marine transport routes

Score = 2

Environmental Effects: Covering the entire foreshore within Area S with concrete is likely to have environmental effects.

Score = 1

Processes and Authorisations: Given the concrete would extend below the mean high tide spring, the Forth Port Authority agreement would be required. It is likely an EIA would also be required which may require a Habitats Regulations Assessment. Given the Ramsar designation of the site, additional authorisations may well be required. Depending on the designation of the works, Fife Council may also need to be consulted. Wider consultations will also be required for work completed within the marine environment.

Score = 2

Stakeholder Support: As noted earlier, stakeholder support could be more difficult to obtain in this area given the relative use of the foreshore. Moray Estates, as landowners, would also need to give approval.

Score = 3

Sustainability: A higher score is given for sustainability on the assumption that armouring materials can be delivered by a marine route. Unwanted materials from, for example, blasting operations can provide a sustainable resource. With minimal social impact, a lower carbon footprint by marine transport and a sustainable resource, overall, this option scores relatively well.

Score = 4

Option S7B – Remove radium to Criterion 1, build replacement slipway and rock armour foreshore and construct marine barrier

The attributes for this option score the same as Option S5. The addition of a marine barrier is not considered to overtly effect the overall scoring.

Option S4 – Remove radium to Criterion 1, cover foreshore with concrete (large slipway)

The attributes for this option score the same as Option S7A. The lack of a marine barrier is not considered to overtly effect the overall scoring.

Area BS (Boat Park Bay South)

Option BS6 – Remove radium to Criterion 1, improve and extend current rock armour to cover the sandy foreshore (strand)

Works Impact: The work will involve access to the grassy platform above the foreshore and to the first 10 to 15m of sandy foreshore. Installation of the new rock armour will clearly have an impact for walkers in the area, and possibly for users of the Sailing Club, but given the likely duration of the works, it is anticipated that the amenity impact will be minimal. This is especially so where transport of materials is by a marine route.

Score = 4

Environmental Effects: The coverage of the sandy foreshore with rock armour is likely to have environmental effects though given the limited extent of the armouring, the overall impact is not as detrimental as that, for example, in Area S or H.

Score = 2

Processes and Authorisations: To be able to undertake this work there will need to be consultation with, and authorisation from, a number of regulatory bodies including Fife Council and Forth Ports Authority.

Score = 3

Stakeholder Support: The work will require agreement from landowners and cooperation from the public using the area. Although the impact from haulage to the local community can be minimised through use of marine transport of materials, the placement of rock armouring across one of the more aesthetically pleasing areas used by the public ranks stakeholder support lower.

Score = 2

Sustainability: A higher score is given for sustainability on the assumption that armouring materials can be delivered by a marine route. Unwanted materials from, for example, blasting operations can provide a sustainable resource. With minimal social impact, a lower carbon footprint by marine transport and a sustainable resource, overall, this option scores relatively well.

Score = 4

Option BS7G – Reinforce current rock armouring and on-going monitoring

The construction work required to implement this option is very similar to Option BS6 above, the main variance being the lack of armouring on the foreshore.

Works Impact: This option would still require areas of the foreshore to be inaccessible to the public during construction works but overall has a low impact.

Score = 4

Environmental Effects: Short term environmental effects could be realised, especially given the Ramsar designation of the site and depending on when works are undertaken. However, the general lack of disturbance of the foreshore and the fact it will largely remain unaltered from pre to post implementation results in a reasonably high score.

Score = 4

Processes and Authorisations: Despite the construction works being limited to above the mean high tide spring, consultation would still be required with Fife Council. Additionally, the remedial monitoring would require regulatory buy-in. Given the complexities with any such process, a moderate score is attributed.

Score = 3

Stakeholder Support: Reinforcement of the current rock armouring is anticipated to be perceived as positive step. However, despite the intense remedial monitoring and removal of radioactive material, this has the potential to be perceived as less robust than, for example, the wholesale covering of areas where past contaminant has been identification.

Score = 2

Sustainability: The sustainability is similar to Option BS6 given the requirement for import of materials to reinforce the rock armouring. Monitoring of the foreshore is considered reasonably

sustainable though personnel will need to visit the site on a regular basis and this will have an associated carbon footprint. However, impact socially is likely to be minimal with positive environmental effects.

Score = 4

Option BS1 – Monitor and remove radium

Works Impact: This option has no real impact on amenity receptors from the current on-going situation. Therefore this options cores very highly.

Score = 5

Environmental Effects: Again, there will be no variance from the current on-going situation and therefore this also scores very highly.

Score = 5

Processes and Authorisations: The use of monitoring and removal of radioactive material would require regulatory buy-in. As noted above, monitoring is a complex process but has also been demonstrably effective. Overall a moderate to low score has been provided.

Score = 2

Stakeholder Support: As noted early, despite the proven success of such an approach, there may be a perception amongst stakeholders that monitoring and radioactive material removal is not as robust as other options.

Score = 2

Sustainability: This would score very highly were it not for the longer term carbon footprint associated with travelling to the site by a monitoring team. Balanced against that is the low social impact and the clear environmental benefit.

Score = 4

Option BS7D – Excavation of strand, screen, replace and replace/reinforce rock armour

Works Impact: The foreshore (excavation), the adjacent grassy platform (rock armouring) and the grassy area adjacent to the headland (screening of arisings) would all likely be required to undertake this option. This would clearly have a negative impact on amenity receptors, with much of the Sailing Club and environs inaccessible. Consequently, this option scores low.

Score = 2

Environmental Effects: Dependent upon the seasonality of the works and duration, the environmental effects from works can be reduced. However, excavation across sections of the foreshore is likely to have some environmental effects with the disturbance of materials.

Score = 3

Processes and Authorisations: The excavation of the foreshore will require consultation and authorisation from a number of consultees. In addition to this, the screening of the arisings will likely require some form of permitting. This option is considered complex to achieve the necessary authorisations.

Score = 2

Stakeholder Support: The benefit of radioactive contamination removal from the foreshore is likely to be perceived as a positive option by the various stakeholders. However, this may be negated somewhat by the works impact (as defined above) resulting in a lower overall score.

Score = 2

Sustainability: The works are likely to be generally contained within the Sailing Club area, minimising the need for haulage though the local residential community. The screened arisings that are deemed suitable are likely to minimise import and provide an anticipated high degree of re-use, significantly reducing carbon footprint. Rock armour, if imported by marine transport, will also have minimal social impact. Overall, this option scores highly for sustainability.

Score = 4

Option BS7E – Excavation of strand to site containment area and replacing/reinforcing rock armour

Works Impact: Similar to Option BS7D, above, the works impact is likely to be high. Although screening of arisings is not necessarily required for infilling of a containment cell, it may be necessary for current buildings and structures to be demolished to provide a suitably sized containment cell, especially given the shallow depth to bedrock across the area. Any such work would have a very high impact on amenity receptors.

Score = 1

Environmental Effects: There are likely to be environmental effects from the excavation of the foreshore and from the construction and infilling of any containment cell. The longer term effects of effectively landfilling radium contamination would also need careful consideration. Any clean imported fill is likely to have lower biotic index than the current foreshore materials.

Score = 2

Processes and Authorisations: In addition to the complexities identified above for excavation of the foreshore and installation of rock armouring, the most difficult authorisation to obtain is considered to be any licence required for the effective landfilling of radium contamination within a containment cell. This option is considered very complex.

Score = 1

Stakeholder Support: Despite the positive impact of removal of contaminated foreshore materials and reinforcing current rock armouring, the option to landfill radioactive arisings is likely to be met with some resistance and there may be a general lack of support with stakeholders. Use of a containment cell may give rise to the perception of blight. Subsequently, this options scores very low.

Score = 1

Sustainability: Minimising the need for transport of foreshore arisings off-site by placement within a containment cell has a degree of sustainability. However, unless a local use for arisings generated from construction of the cell can be determined, this option will effectively have the same sustainability as that of off-site disposal. Subsequently, this scores very low.

Score = 1

Option BS7F – Excavation of strand, dispose off-site, replace and replace/reinforce coastal defences

Generally, this option is very similar in detail to Option BS7D, above, and scores identically for the same reasoning with the exception of:

Sustainability: The excavation and off-site disposal of foreshore arisings together with the import of clean materials results in a high carbon footprint, impact to the local residential community and transfer of all contamination to an off-site location. Despite the positive element derived from marine transport of rock armouring materials, this option still scores very low due to the likely social, environmental and economic impacts.

Score = 1

Area BN (Boat Park Bay North)

The options, scoring and justification for Area BN options are identical to those in Area BS as is shown in Table 2. Rather than repeat the options, the reader is directed to the section above for Area BS. The exception to this is Sub-Area BN-Z, a zone within Area BN where specific remedial options have been considered. These are discussed below.

Sub-Area BN-Z (Boat Park Bay North Zone 1)

Option BNZ4- Install rock armour

Works Impact: Installation of rock armour across BN-Z will have minimal impact on amenity receptors given the small scale of work involved and the limited area. Access will be required to the foreshore and grassy platform landward but is unlikely to affect wider use. This option scores highly.

Score = 4

Environmental Effects: The environmental effects of installing rock armour are considered low. Any residual impact though can be minimised through the design of the rock armouring. The erosion identified at BN-Z is attributable, in part, to the abrupt finish of the current rock armouring. The new rock armouring will need to be tapered off rather than finish abruptly to ensure the wave erosion currently experienced in BN-Z is not simply transferred down drift.

Score = 4

Processes and Authorisations: There will need to be consultation and authorisation from a number of consultees including, amongst others, Fife Council. The complexity of gaining authorisations is considered neither high nor low resulting in a moderate score.

Score = 3

Stakeholder Support: Given the short duration of the anticipated works and the benefit of preventing further migration of potential contamination landward to the forshore, stakeholder support is anticipated to be positively achieved.

Score = 4

Sustainability: The small area requiring installation of rock armouring will likely have materials transported in by road (unless part of a wider scheme where materials are transported in by marine routes). The volume of rock required to be imported is likely to be small and consequently, the haulage of such materials is likely to have a reasonably low impact on the

local residential community. However, there would be a reasonable carbon footprint for transportation of rock though this is off-set slightly by the environmental benefit.

Score = 3

Option BNZ7G – Excavate localised landward infill to site containment area and install rock armour

Works Impact: Two areas of the Sailing Club would be impacted by undertaking this option. Firstly, the area of ashy infill at BN-Z which will require excavating, and secondly, the area in which a containment cell would need to be constructed. This could have an impact on amenity receptors.

Score = 2

Environmental Effects: There could be environmental effects from excavation of both the ashy infill and construction of a containment cell in the short term. This results in a moderate score.

Score = 3

Processes and Authorisations: Authorisation and/or licences for the containment cell are considered the most complex aspect for this option. Consequently, a very low score is given.

Score = 1

Stakeholder Support: Similar to processes and authorisations, stakeholders including landowners and amenity receptors are unlikely to be favourable for a containment cell approach. The potential perception for land to be blighted is also likely. This options scores very low.

Score = 1

Sustainability: The use of an on-site containment cell appears more sustainable but unless a local use for materials excavated to construct any cell can be identified, this option equates to off-site disposal. This would require haulage wagons to transport cell construction arisings through the local residential area resulting in a higher carbon footprint. The environmental benefit would then be questionable. Overall, this scores very low.

Score = 1

Option BNZ5B – Excavate localised landward ashy infill for off-site disposal and install rock armour

Works Impact: The excavation of the ashy infill and rock armour installation is within a discrete area and will have a low impact on amenity receptors. Much of the area could still be used by the Sailing Club and other users. However, the off-site disposal, combined with import of clean fill and rock for armouring is likely to have an impact on local residents. The relatively short duration of the works would, however, minimise such impact.

Score = 3

Environmental Effects: The environmental effects of removing the ashy infill are considered to be low and the benefits by importing clean fill are positive, especially when combined with installation of rock armouring. This results in a reasonable score.

Score = 4

Processes and Authorisations: The required authorisations to undertake this work is not considered complex. However, the relevant authorisations to dispose of radioactive arisings are considered more complex. Therefore, a low score applies.

Score = 2

Stakeholder Support: The positive benefit of removal of radioactive material is considered to generate stakeholder support for this option. This, combined with the installation of rock armour, gives a reasonable score.

Score = 4

Sustainability: The off-site disposal of radium contamination and the subsequent import of clean infill and rock for armouring will have a consequential carbon footprint and associated social impact from haulage wagon movements through the residential area. However, there is a clear environmental benefit in removal of radium contamination. Overall, this provides a very low score.

Score = 1

Option BNZ3 – Excavate localised landward ashy infill for off-site disposal, replace with clean import

Works Impact: This option is considered to have a moderate impact on amenity receptors as a consequence of the excavation area becoming inaccessible to the public and the process of consigning and loading of waste materials.

Score = 3

Environmental Effects: The environmental effects from excavating ashy infill and replacing with clean import are considered to be low resulting in a reasonably high score.

Score = 4

Processes and Authorisations: As for Option BNZE, the required authorisations to undertake this work is not considered complex. However, the relevant authorisations to dispose of radioactive arisings are considered more complex together with regulatory buy-in to not install rock armouring. Therefore, a low score applies.

Score = 2

Stakeholder Support: Removal of radioactive infill and replacement with clean import is considered a positive benefit that will have buy-in from stakeholders and consequently scores highly.

Score = 4

Sustainability: For the same reasoning as Option BNZ5B above, the sustainability of this option is considered very low.

Score = 1

Option BNZ1 – Monitor and remove radioactive material

Works Impact: The impact of remedial monitoring and removing radioactive material is considered on a par with current monitoring works and consequently has a very low impact on amenity receptors.

Score = 5

Environmental Effects: Likewise, with no changes to the current environmental conditions, the impact of monitoring is negligible and consequently a very low impact to biodiversity.

Score = 5

The use of monitoring and removal of radioactive material would require regulatory buy-in. As noted above, monitoring is a complex process but has also been demonstrably effective. Overall a moderately low score has been provided.

Score = 2

Stakeholder Support: As noted early, despite the proven success of such an approach, there may be a perception amongst stakeholders that monitoring and radioactive material removal is not as robust as other options.

Score = 2

Sustainability: This would score very highly were it not for the longer term carbon footprint associated with travelling to the site by a monitoring team. Balanced against that is the low social impact and the clear environmental benefit.

Score = 4

Dalgety Bay Management Strategy Options - Attribute Table 2

See Drawing 23218/SHR/392 for Area Locations				Score	Attribute Min (1) Max (5)	***Construction Works Impact - Amenity*** *Very high impact* *Very low impact*	***Environmental Effects - Biodiversity*** *Very high impact* *Very low impact*	***Processes and Authorisations*** *Numerous and difficult* *Few and achievable*	***Stakeholder Support*** *Unacceptable* *Certain acceptability*	***Sustainability*** *Not sustainable* *Very high sustainability*	**Total Table 2 Score**	***Combined Score (Table 1A/B + Table 2)***	**Rank**
Remediation Area	**Option Identifier** (score from Table 1A/B)		**Description**										
Area H (Headland)	H7I	17	Excavate, screen, replace foreshore, reinforce armouring stone and construct marine barrier (H1+H5+H6)			2	2	2	2	3	11	28	
Area H (Headland)	H7J	17	Excavate to site containment cell, import clean, reinforce armouring stone and constrcut marine barrier (H2+H5+H6)			2	2	1	1	3	9	26	
Area H (Headland)	H7K	19	Excavate, screen, off-site disposal, import clean, reinforce armouring stone and constrcut marine barrier (H3+H5+H6)			2	2	2	2	1	9	28	
Area H (Headland)	H4	17	Reinforce/replacement of current armour stone,extend over foreshore			4	3	3	3	4	17	34	**1**
Area H (Headland)	H7A	16	Excavate, screen, replace foreshore and reinforce armour stone(H1+H5)			2	2	2	2	3	11	27	
Area H (Headland)	H7E	17	Excavate, screen, off-site disposal, import clean and reinforce armouring stone (H3+H5)			2	2	2	2	1	9	26	
Area H (Headland)	H7G	16	Reinforce/replace current armour stone, extend over foreshore and construct marine barrier (H4+H6)			4	3	2	3	4	16	32	**2**
Area H (Headland)	H7C	15	Excavate to containment cell, import celan and reinforce armour stone (H2+H5)			2	2	1	1	3	9	24	
Area S (Slipways)	S1	15	Excavate, screen, replace foreshore			2	2	2	2	4	12	27	
Area S (Slipways)	S3	18	Excavate, screen, off-site disposal, import clean			2	2	2	3	2	11	29	**3**

See Drawing 23218/SHR/392 for Area Locations				Score	Attribute Min (1) Max (5)	Construction Works Impact - Amenity Very high impact Very low impact	Environmental Effects - Biodiversity Very high impact Very low impact	Processes and Authorisations Numerous and difficult Few and achievable	Stakeholder Support Unacceptable Certain acceptability	Sustainability Not sustainable Very high sustainability	Total Table 2 Score	Combined Score (Table 1A/B + Table 2)	Rank
Remediation Area	**Option Identifier** (score from Table 1A/B)		**Description**										
Area S (Slipways)	S5	17	Removal of radium to meet Criterion 1, build new slipway and cover foreshore (armour)			2	2	3	3	4	14	31	**1**
Area S (Slipways)	S2	15	Excavate foreshore and remove to site containment area with clean import			2	2	1	1	4	10	25	
Area S (Slipways)	S7A	16	Removal of radium to meet Criterion 1, concrete over foreshore and construct marine barrier (S4+S6)			2	1	2	3	4	12	28	
Area S (Slipways)	S7B	16	Removal of radium to meet Criterion 1, build new slipway, cover foreshore (armour) and construct marine barrier (S5+S6)			2	2	3	3	4	14	30	**2**
Area S (Slipways)	S4	15	Removal of radium to meet Criterion 1, concrete over foreshore			2	1	2	3	4	12	27	
Area BS (Boatyard South)	BS6	21	Removal of radium to meet Criterion 1, reinforce/replace and extend current rock armour to cover the upper sandy foreshore			4	2	3	2	4	15	36	**2**
Area BS (Boatyard South)	BS7G	20	Reinforce/replace current rock armouring and on-going monitoring (BS5+BS1)			4	4	3	2	4	17	37	**1**
Area BS (Boatyard South)	BS1	18	Monitor and remove radium contamination			5	5	2	2	4	18	36	**2**
Area BS (Boatyard South)	BS7D	17	Excavation of strand, screen, replace and reinforce/replace current rock armouring (BS2+BS5)			2	3	2	2	4	13	30	
Area BS (Boatyard South)	BS7E	18	Excavation of strand to containment cell, import clean and reinforce/replace current rock armouring (BS3+BS5)			1	2	1	1	1	6	24	
Area BS (Boatyard South)	BS7F	18	Excavation of strand, screen, off-site disposal, import clean and reinforce/replace current rock armouring (BS4+BS5)			2	3	2	2	1	10	28	

				Score	Attribute	Construction Works Impact - Amenity	Environmental Effects - Biodiversity	Processes and Authorisations	Stakeholder Support	Sustainability	Total Table 2 Score	Combined Score (Table 1A/B + Table 2)	
					Min (1)	Very high impact	Very high impact	Numerous and difficult	Unacceptable	Not sustainable			
See Drawing 23218/SHR/392 for Area Locations					Max (5)	Very low impact	Very low impact	Few and achievable	Certain acceptability	Very high sustainability			Rank ↓
Remediation Area	**Option Identifier** (score from Table 1A/B)		**Description**										
Area BN (Boatyard North)	BN6	21	Removal of radium to meet Criterion 1, reinforce/replace and extend current rock armour to cover the upper sandy foreshore			4	2	3	2	4	15	36	**2**
Area BN (Boatyard North)	BN7G	20	Reinforce/replace current rock armouring and on-going monitoring (BN5+BN1)			4	4	3	2	4	17	37	**1**
Area BN (Boatyard North)	BN1	18	Monitor and remove radium contamination			5	5	2	2	4	18	36	**2**
Area BN (Boatyard North)	BN7D	17	Excavation of strand, screen, replace and reinforce/replace current rock armouring (BN2+BN5)			2	3	2	2	4	13	30	
Area BN (Boatyard North)	BN7E	18	Excavation of strand to containment cell, import clean and reinforce/replace current rock armouring (BN3+BN5)			1	2	1	1	1	6	24	
Area BN (Boatyard North)	BN7F	18	Excavation of strand, screen, off-site disposal, import clean and reinforce/replace current rock armouring (BN4+BN5)			2	3	2	2	1	10	28	
Area BN-Z1 (Boatyard North Zone 1)	BNZ4	21	Install rock armour			4	4	3	4	3	18	39	**1**
Area BN-Z1 (Boatyard North Zone 1)	BNZ5A	21	Excavate localised landward ashy infill to on-site containment area, replace with clean import and install rock armour			2	3	1	1	1	8	29	
Area BN-Z1 (Boatyard North Zone 1)	BNZ5B	22	Excavate localised ashy infill for off-site disposal, replace with clean import and install rock armour			3	4	2	4	1	14	36	**2**
Area BN-Z1 (Boatyard North Zone 1)	BNZ3	20	Excavate localised ashy infill for off-site disposal, replace with clean import			3	4	2	4	1	14	34	
Area BN-Z1 (Boatyard North Zone 1)	BNZ1	18	Monitor and remove radium contamination on foreshore			5	5	2	2	4	18	36	**2**

Annex D
Tier 3: Attribute Table 3 - Cost

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Dalgety Bay Management Strategy Options - Table 3 Summary Cost Scoring

Remediation Area	Option Identifier	Description	Combined Scores from Table 1A/B and Table 2	Indicative Construction Cost Ranking	Indicative Maintenance Cost Ranking	Longer Term Maintenance Required	Score
Area H (Headland)	H4	Reinforce/replacement of current armour stone,extend over foreshore	34	4	4	✓	42
	H7G	Reinforce/replace current armour stone, extend over foreshore and construct marine barrier (H4+H6)	32	2	5	✓	39
Area S (Slipway)	S5	Removal of radium to meet Criterion 1, build new slipway and cover foreshore (armour)	31	5	3	✓	39
	S7B	Removal of radium to meet Criterion 1, build new slipway, cover foreshore (armour) and construct marine barrier (S5+S6)	30	3	3	✓	36
	S3	Excavate, screen, off-site disposal, import clean	29	2	5	×	36
Area BS (Boatyard South)	BS7G	Reinforce/replace current rock armouring and on-going monitoring (BS5+BS1)	37	4	2	✓	43
	BS6	Removal of radium to meet Criterion 1, reinforce/replace and extend current rock armour to cover the upper sandy foreshore	36	2	4	✓	42
	BS1	Monitor and remove radium contamination	36	5	3	×	44
Area BN (Boatyard North)	BN7G	Reinforce/replace current rock armouring and on-going monitoring (BN5+BN1)	37	4	2	✓	43
	BN6	Removal of radium to meet Criterion 1, reinforce/replace and extend current rock armour to cover the upper sandy foreshore	36	2	4	✓	42
	BN1	Monitor and remove radium contamination	36	5	3	×	44
Area BN-Z (Boatyard North Zone 1)	BNZ4	Install rock armour	39	3	2	✓	44
	BNZ5B	Excavate localised ashy infill for off-site disposal, replace with clean import and install rock armour	36	1	4	×	41
	BNZ1	Monitor and remove radium contamination on foreshore	36	4	1	×	41

Note: Cost ranking scores are designed to be consistent with Tables 1A, 1B and 2 such that a higher score (a positive attribute for that option) indicates a lower cost and a lower score (a negative attribute for that option) indicates a high cost.

Annex E
Example Construction Flow Chart

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Example Construction Flowchart for Rock Armouring Foreshore