Kyleakin Fish Feed Factory

Marine Harvest

Environmental Impact Assessment - Volume 2 of 4: Main Report

Chapter 5: Hydrogeology and Geology

Final

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Contents

5. Hydrogeology and Geology

5.1 Introduction

This chapter presents the expected impacts of the Proposed Development in relation to geology, groundwater and contaminated land.

This includes impacts to bedrock and superficial geology, mineral extraction, contaminated land, groundwater and associated receptors including private water supplies (PWS).

Geological impacts can occur due to excavating or masking exposures of rocks or superficial geological deposits of particular scientific interest, particularly if the features of interest are not reproduced elsewhere in the area. Impacts can also include restrictions on existing or potential future commercial exploitation of resources. Conversely, previous exploitation of resources can impose constraints on the development; for example, where land has become unstable due to mining or has been contaminated by previous land uses

The assessment has identified contaminated land sources associated with previous site land use and activities; and potential impacts have been determined using previous assessment and Phase One site investigation.

During construction, there is an inherent risk of spillage or leakage of fuel or oil from storage tanks or construction plant. Without suitable mitigation measures, these pollutants could enter aquifers and degrade water quality. Construction work can disrupt and / or pollute of superficial and bedrock aquifers.

Similarly, during operation groundwater flows can also be intercepted or altered by permanent excavations, subsurface constructions and other significant changes to landform.

The assessment is supported by the following:

- Appendix 5.1: Summary of previous assessments.
- Appendix 5.2: Fairhurst drawings.
- Appendix 5.3: Excavated material chemical testing and screening assessment.
- Figure 5.1: Contaminated Land identified sources location.

5.2 Methodology

5.2.1 Study Area

The assessment covers a study area of 250m around the Development Area, as shown on **Figure 5.1.**

5.2.2 Baseline Data

Baseline conditions were determined through review of a desk-based assessment conducted by Fairhurst (Fairhurst 2016) and consultation with statutory consultees. This was augmented by intrusive ground investigation works designed by Fairhurst and conducted by BAM Ritchies.

Baseline conditions cover the following aspects of ground conditions:

- bedrock and superficial geology;
- mineral extraction;
- groundwater environment and associated receptors; and
- contaminated land.

5.2.2.1 Desk Based Assessment

The desk-based assessment included a review of the following information:

- British Geological Survey (BGS) data, including BGS Superficial and Bedrock Geological Maps, BGS Hydrogeological Maps and Groundwater Vulnerability Maps (BGS 1995) and other relevant BGS publications (BGS 2016);
- Envirocheck Report containing Ordnance Survey (OS) historical maps dating back to 1880 for information on former land use, potential contamination and physical hazards and information on site sensitivity;
- Scottish Environmental Protection Agency (SEPA) Groundwater Body Classification, accessed via Scotland's Environment website (Scotland's Environment, 2016); and
- results of previous studies conducted by Fairhurst (The Phase I Environmental Due Diligence Report).

5.2.2.2 Intrusive Ground Investigation

Ground Investigation (GI) works were designed by Fairhurst and conducted by BAM Ritchies between 23 November 2015 and 18 December 2015.

The investigation consisted of 16 rota-sonic boreholes, 59 mechanically excavated trial pits and 16 hand excavated trial pits, all of which are shown in **Figure 5.1**. The investigation positions were located across the entire site area, and also an area outside the Development Area, located to the south-east of the site as shown in **Appendix 5.2**. Samples of soils and encountered groundwater were collected and sent to Exova Ltd for chemical analysis.

Fifteen boreholes were completed with groundwater and gas monitoring installations. Groundwater level data were collected on 7 January 2016 and 10 February 2016, while gas monitoring was undertaken on six occasions between 7 January 2016 and 29 February 2016. Eight of the trial pits were used for infiltration testing.

This assessment is based on the final Factual Ground Investigation Report (including borehole logs, in-situ testing and laboratory analysis data) prepared by Fairhurst (Fairhurst, 2016).

In addition, 20 sediment samples were collected from the floor of Loch Alsh by Aspect Land & Hydrographic Surveys Ltd (ALHS) between 12 July 2016 and 14 July 2016 using vibrocore and surface grab techniques in the proposed area to be excavated. These samples were sent to Environmental Scientifics Group where sediment and leachate chemical analysis was conducted in order to ascertain the physiochemical properties of these sediments. The results were reported in Kyle Akin Geotechnical Survey (ALHS 2016).

5.2.3 Consultation

Consultations were undertaken with a number of statutory consultees in order to assess geological and hydrogeological impacts and contaminated land issues. These included the following:

- The Highland Council for information on former contaminated land use, Part IIA determinations, PWS, licensed fuel storage and any additional relevant information; and
- SEPA for information on licenced groundwater abstractions on former and current contaminated land use.

Further information on the consultation process is provided in **Chapter 3: Development Design and Alternatives** of this ES.

5.2.4 Impact Assessment

The impacts in relation to geology, hydrogeology and contaminated land have been assessed individually as per the methodologies provided below. The criteria outlined in **Tables 5.1 to 5.5 and 5.7 to 5.9** are used to assess the potential impacts on sensitive receptors as a result of the construction of the Proposed Development. The overall impact of the Proposed Development is then determined through a combination of

these impacts. Impacts of Slight / Moderate and above significance are highlighted as at these significance levels it is considered that mitigation would be required.

5.2.4.1 Geology

For bedrock and superficial geology, features of geological importance and mineral extraction the sensitivity and magnitude criteria provided in **Table 5.1 and 5.2** were used to assign sensitivity and magnitude. The impact significance was then determined in line with **Table 5.3**.

Table 5.1 : Sensitivity Criteria for Geology Assessment

Likelihood	Definition
High	Areas containing unique or rare geological or geomorphological features considered to be of national interest e.g. Sites of Special Scientific Interest (SSSI) and Geological Conservation Review (GCR).
Medium	Areas containing features of designated regional importance considered worthy of protection for their educational, research, historic or aesthetic importance e.g. Regionally Important Geological Sites (RIGS). Geological resources of national / regional importance.
Low	Features not currently identified as SSSI, GCR or RIGS but that may require specific protection in the future. Geological resources of local importance.
Negligible	Features not currently protected and unlikely to require specific protection in the future. No exploitable geological resources.

Table 5.2 : Magnitude Criteria for Geology Assessment

Likelihood	Definition
High	Total loss or partial loss (greater than 50%) or total loss of a site, or where there would be complete severance of a site such as to affect the value of the site.
Medium	Loss of part (between approximately 15% and 50%) of a site, major severance, major effects to the setting, or disturbance such that the value of the site would be affected, but not to a major degree.
Low	Loss of part (up to 15%) or a medium effect on its setting, or where there would be a minor severance or disturbance such that the value of the site would not be affected.
Negligible	Very slight change from baseline condition. Change hardly discernible, approximating to 'no change' conditions.

Table 5.3 : Matrix for Determination of Impact Significance for Geology Assessment

Magnitude	Sensitivity			
	Negligible	Low	Medium	High
Negligible	Negligible	Negligible	Negligible / Slight	Slight
Low	Negligible	Negligible / Slight	Slight / Moderate	Moderate
Medium	Negligible / Slight	Slight / Moderate	Moderate	Moderate / Substantial
High	Slight	Moderate	Moderate / Substantial	Substantial

5.2.4.2 Hydrogeology

The assessment considers groundwater sensitivity in the context of hydrogeological conditions including groundwater resources. Criteria for the definition of groundwater sensitivity and magnitude are shown in **Table 5.4 and 5.5**.

The criteria for the definition of the magnitude of impact on quality and yield of abstractions are based primarily on the type of depth of excavation facing the abstraction. However, where appropriate, the vulnerability of groundwater flow to sub-surface disruptions is also considered to refine the magnitude of impact.

The impact significance for groundwater aspects was then determined using the matrix as shown in **Table 5.3**.

Table 5.4 : Sensitivity Criteria for Groundwater

Likelihood	Definition
High	Local aquifer(s) constitutes a valuable resource because of its high quality and yield, or extensive exploitation for public, private domestic and / or agricultural (i.e. feeding ten or more properties) and / or industrial supply. Important sites of nature conservation dependent on groundwater as per sensitivity criteria attributed within Chapter 11: Terrestrial Ecology.
Medium	Local aquifer(s) are of limited value either because of some quality impairment or because exploitation of local groundwater is not extensive (i.e. private domestic and/or agricultural supply feeding less than 10 properties). Local areas of nature conservation known to be sensitive to groundwater impacts as per sensitivity criteria attributed within Chapter 11: Terrestrial Ecology.
Low	Poor groundwater quality and / or low permeability make exploitation of groundwater unlikely. Minor areas of nature conservation with a degree of groundwater dependency as per sensitivity criteria attributed within Chapter 11: Terrestrial Ecology.
Negligible	Very poor groundwater quality and / or very low permeability make exploitation of groundwater unfeasible. No known past or existing exploitation of this water body. Changes to groundwater are irrelevant to local ecology.

Table 5.5 : Magnitude Criteria for Groundwater

Likelihood	Definition
High	Major permanent or long-term change to groundwater quality or available yield. Existing resource use is irreparably impacted upon. Changes to quality or water table level would have an impact upon local ecology.
Medium	Changes to the local groundwater regime are predicted to have a slight impact on resource use. Minor impacts on local ecology may result.
Low	Changes to groundwater quality, levels or yields do not represent a risk to existing resource use or ecology.
Negligible	Very slight change from groundwater baseline conditions approximating to a 'no change' situation.

5.2.4.3 Contaminated Land

In line with industry standards the assessment focuses on the potential for impacts on receptors as a consequence of encountering contaminated land using a conceptual site model (CSM) proposed for the Proposed Development. A receptor can be a person (including construction workers), the water environment, flora, fauna or building / structures. The CSM represents a network of relationships between potential sources of contamination from within the study area and exposure of the receptors through different pathways. The potential receptors (refer to **Table 5.6**) and pathways have been compiled based on the legal definitions used in Part IIA of the Environment Protection Act 1990, as provided in the Statutory Guidance (Scottish Executive 2006).

Historical sources of contaminated land have been identified in the baseline information **(Section 5.3: Baseline Conditions**).

The potential pollutant pathways (PP) and type of receptors used within the assessment are provided in **Table 5.6**, with individual references for linkages, i.e. PP1 to PP22.

Table 5.6 : Potential Pollutant Pathways and Receptors

Pollutant Pathway	Receptor	Pathway
Construction		
PP1	Human Health (Construction)	Ingestion, inhalation and dermal contact with soils, soil dust, deep and shallow groundwater and surface water.
PP2		Migration of ground gases into shallow pits or site buildings.
PP3	Off-site Receptors (Local residents and transient (foot, road and rail) traffic)	Ingestion, inhalation and dermal contact with wind-blown dust created during excavation works.
PP4		Migration of ground gases into homes or workplaces through preferential pathways created during construction posing a potential asphyxiation / explosion risk.
PP5	Groundwater – Superficial Aquifers	Leaching and migration of contaminants.
PP6	Groundwater – Bedrock Aquifers	Migration of contaminants or contaminated shallow groundwater into the deeper rock aquifer.
PP7	Surface Waters	Migration of contaminated shallow groundwater through superficial deposits or made ground.
PP8		Runoff from contaminated source(s).
PP9		Migration of contaminated bedrock groundwater towards surface water receptor.
PP10		Discharge of intercepted contaminated groundwater during passive or active dewatering.
PP11	Ecological Receptors (water dependant habitats and agricultural land/livestock)	Inhalation, ingestion and direct contact with contaminated soils / water.
PP12	Buildings / Structures	Explosion risk due to migration and build-up of ground gases / vapours
Operational		
PP13	Human Health (Operational)	Ingestion, inhalation and dermal contact with soils, soil dust, deep and shallow groundwater, surface water in the long term during routine maintenance activities e.g. drainage inspections.
PP14		Migration of ground gases into confined spaces e.g. service pits, accommodation buildings creating an asphyxiation / explosion risk.
PP15	Off-site Receptors	Ingestion, inhalation and dermal contact with wind-blown dust from contaminated soils reused within the site.
PP16		Migration of ground gases into homes or workplaces through preferential pathways remaining following construction thus posing a potential asphyxiation / explosion risk.
PP17	Groundwater – Superficial Aquifers	Leaching and migration of contaminants.
PP18	Groundwater – Bedrock Aquifers	Migration of contaminated shallow groundwater into the deeper rock aquifer.
PP19	Surface Water	Migration of shallow groundwater through superficial deposits or made ground.
PP20		Runoff from contaminated source(s).
PP21		Migration of contaminated shallow groundwater through drainage channels and associated granular bedding materials or engineered structures.
PP22		Discharge of intercepted contaminated groundwater.
PP23	Ecological Receptors	Inhalation, ingestion and direct contact with contaminated soils / water.

Pollutant Pathway	Receptor	Pathway
PP24	Buildings / Structures	Explosion risk due to migration and build-up of ground gases / vapours

For the purposes of this assessment, the CSM disregards those pathways that are incomplete and therefore cannot pose a risk to any of the identified receptors. Where a source, pathway and receptor combination exists this is referred to as a complete pollutant linkage, and a generic qualitative risk assessment has been undertaken.

Potential impacts are discussed in terms of likelihood as shown in **Table 5.7** and magnitude / consequence as shown in **Table 5.8**. The generic qualitative risk assessment is then undertaken based on the matrix shown in **Table 5.9**.

Table 5.7 : Likelihood Criteria for Contaminated Land Assessment

Likelihood	Definition
High Likelihood	There is a complete pollution linkage of an event that either appears very likely in the short term and almost inevitable over the long-term, or there is evidence at the receptor of harm or pollution.
Likely	There is a complete pollution linkage and all the elements are present and available, which means that it is probable that an event will occur. Circumstances are such that an event is not inevitable, but possible in the short-term and likely over a long-term.
Low Likelihood	There is a complete pollution linkage and the circumstances are possible under which an event could occur. However, it is by no means certain that even over a longer period such an event would take place, and is less likely in the shorter term.
Unlikely	There is a complete pollution linkage but circumstances are such that it is improbable that an event would occur even in the very long-term.

Table 5.8 : Magnitude (Consequence) Criteria for Contaminated Land Assessment

Likelihood	Definition
Severe	Short-term (acute) damage to human health (significant harm). Pollution of sensitive water resources as a result of short-term exposure. Damage to a particular ecosystem as a result of acute exposure. Catastrophic damage to buildings / property.
Medium	Long-term (chronic) damage to human health (significant harm). Pollution of sensitive water resources as a result of chronic exposure. A significant change in a particular ecosystem, or organism forming part of such an ecosystem.
Mild	Pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services. Damage to sensitive buildings / structures / services or the environment.
Minor	Harm (not necessarily significant), which may result in financial loss or require expenditure to resolve. Non-permanent health affects to human health. Easily reparable damage to buildings, structures and services. No harm to environment.

Table 5.9 : Matrix for Determination of Generic Qualitative Risk Assessment for Contaminated Land

Magnitude	Likelihood			
	Unlikely	Low Likelihood	Likely	High Likelihood
Minor	Very Low	Very Low	Low	Moderate / Low
Mild	Very Low	Low	Moderate / Low	Moderate
Medium	Low	Moderate / Low	Moderate	High

Magnitude	Likelihood			
	Unlikely	Low Likelihood	Likely	High Likelihood
Severe	Moderate / Low	Moderate	High	Very High

5.2.4.4 Mitigation

Potential mitigation measures to reduce identified impacts have been considered during this assessment and are discussed in **Section 5.5 (Mitigation)**.

5.2.5 Limitations

Consultation with nearby landowners regarding PWS was not conducted. The risk is deemed to be low but some PWS may not be recorded with the local authority and the presence of unidentified PWS cannot be ruled out.

No bedrock groundwater monitoring installations were installed as part of the GI works. Therefore it is not possible to make definitive comments on the bedrock groundwater levels across the site, nor the direction on groundwater flow.

It should be noted that the nature of taking representative samples means that all soils over the whole site cannot be analysed. Therefore, there is the possibility that other isolated pockets of contamination may be present. As with any site that has previously been developed, the presence of buildings and below and above ground services has restricted locations where investigations can be undertaken.

This assessment is based upon third party information from the Phase II GI report (Fairhurst, 2016) and sediment sampling results (Kyle Akin Geotechnical Survey, 2016). Key outcomes of these reports, the rationale behind the siting of the GI positions and the assessment criteria used in the reports have been reviewed by Jacobs. However, a full technical appraisal of Fairhurst's and Aspect Land and Hydrographic Surveys' work is beyond the scope of this report and has not been completed.

5.3 Baseline Conditions

5.3.1 Geology

5.3.1.1 Bedrock Geology

BGS 1:50,000 geology maps indicate the Proposed Development is underlain by Neoproterozoic sandstone of the Applecross Formation. Borehole logs from the 2015 GI report the bedrock to be strong to very strong fine to medium grained Psammite, mostly unweathered. Depth to bedrock was recorded between 9mbgl and 39mbgl, with depths to rockhead generally increasing towards the north of the site. As a result of this highly variable depth to rockhead it was concluded the bedrock profile at the site is very steeply bedded, up to approximately 70° in places and falling from shallower depth onshore to greater depth at the frontage of Loch Alsh / Kyle Akin (Fairhurst, 2016).

BGS mapping did not record the presence of any rock faulting in the vicinity of the site.

As per definitions in **Table 5.1**, bedrock geology within the study area is considered to be of negligible sensitivity.

5.3.1.2 Superficial Geology

Superficial deposits in the western and central portion of the Development Area are primarily comprised of late Devensian raised marine deposits, described by BGS as poorly sorted silty sand, gravel and cobbles. Marine beach deposits comprised of shingle, sand, silt and clay, which may be bedded or chaotic, are located in the north-east of the study area near the existing pier, and alluvium (compressible silty clay, with possible layers of

silt, sand, peat and basal gravel) is mapped to the southern portion of the Development Area in the vicinity of the existing reservoir and burn.

Available previous GI broadly supports the descriptions of the superficial units as described above, with silty sand and gravel with a low to medium cobble count being the predominant natural superficial material being encountered. A layer of firm to very stiff sandy clay was recorded in nine boreholes, generally recorded at depth within the sequence.

Made ground was encountered predominantly in the eastern portion of the Development Area and was comprised of reworked silty fine to coarse sand and gravel of various lithologies, with occasional fragments of timber, plastic, metal, textile and road base and quarry backfill (Psammite gravel) material. Maximum thickness of these deposits was 9m with greatest thicknesses located at the pier and also in the south-east corner of the site, adjacent to the burn.

As per descriptions in **Table 5.1** all of these superficial deposits are considered to be of negligible sensitivity.

Peat was encountered in two locations during the GI; a large area to the south-east of the Development Area outside the Development Area boundary and an area in the south-west of the Development Area between the reservoir and the settlement pond. These deposits were described as dark brown / black pseudofibrous to amorphic peat with occasional subangular to subrounded cobbles. Peat was encountered in the Development Area between 0.7m and 4mbgl, with maximum proven thickness to be 2m. The large area of peat to the south-east of the Development Area is believed to be up to 6m deep based upon an earlier GI conducted under instruction by the previous site owner, Redlands Aggregates Ltd (Fairhurst 2016). A peat thickness contour figure based upon the GI results was created by Fairhurst and is presented in **Appendix 5.2**.

Based upon this information the sensitivity of the peat deposits is assigned as Low.

5.3.1.3 Mineral Extraction

The Development Area is within an inactive area of a larger sand and gravel quarry. Due to the history of the study area, where local sand and gravel exploitation is known to have taken place, the potential for further future exploitation as a local natural resource cannot be excluded and as such is considered to be of low sensitivity.

5.3.2 Hydrogeology

BGS classify the Psammite sandstone bedrock underlying the Proposed Development as the Torridon Group, a low productivity aquifer comprised of sandstone and mudstone yielding small amounts of groundwater. Superficial deposits within the study area are classified as a non-aquifer.

SEPA describe the underlying aquifer as Skye South, and classified this water body as having Good status for both groundwater quality and quantity in 2013, with medium confidence.

The Groundwater Vulnerability Map of Scotland (BGS, 1995) indicates that the superficial deposits within the study area are moderately permeable, with intermediate leaching potential (i.e. moderate ability to attenuate diffuse pollution).

The hydrogeological characteristics of superficial and bedrock units within the study area are summarised in **Table 5.10.**

Table 5.10 : Hydrogeological Characteristics of Superficial and Bedrock Units

Geological Unit		Geological Characteristic	Hydrogeological Characteristic	Sensitivity of Groundwater Within Unit
Superficial	Made Ground	Reworked silty fine to coarse sand and gravel	Local groundwater potential.	Negligible

Geological Unit		Geological Characteristic	Hydrogeological Characteristic	Sensitivity of Groundwater Within Unit
	Raised Marine Deposits	Poorly sorted silty sand, gravel and cobbles	Local groundwater potential.	Medium
	Marine Beach Deposits	Shingle, sand, silt and clay	Local groundwater potential.	Medium
	Alluvium	Composed of variable sediments including clay, silt, sand and gravel.	Local groundwater potential. Groundwater system is expected to be hydraulically connected to surface water.	Medium
	Peat	Decomposed organic deposits.	Very poor groundwater potential due to compacted nature, low permeability and limited spatial extent.	Low (from a water resource point of view)
Bedrock	Applecross Formation	Psammite	A low productivity aquifer comprised of yielding small amounts of groundwater.	Low

5.3.2.1 Abstractions

No groundwater abstractions have been identified within the study area.

5.3.2.2 Groundwater Monitoring

Groundwater level data collected between 7 January 2016 and 29 February 2016 indicate that depth to groundwater within the Development Area ranges between 1.30mbgl and 5.82mbgl (Fairhurst, 2016), with higher groundwater levels recorded in the south-western portion of the Development Area. No information exists on bedrock groundwater levels.

5.3.2.3 Groundwater Flow

Groundwater flow within the superficial deposits is likely to be controlled by surface topography, with the results of an hydraulic gradient assessment indicating that groundwater flows towards the north and north-east, in the direction of Loch Alsh (Fairhurst, 2016). The direction of flow of any bedrock groundwater is unconfirmed, however it is suspected to be towards the north due to the proximity of the sea.

5.3.2.4 Groundwater Quality

Baseline groundwater quality is based on previous assessment and therefore discussed in **Appendix 5.1.**

5.3.2.5 Ecological Receptors with Potential Groundwater Component

A small area of sedge and rush dominated habitat has been identified on the eastern fringe of the settlement pond. The pond is expected to be fed by direct rainfall, surface water run-off and potential land drainage, as well as a potential proportion of groundwater. Based on this understanding, this habitat is not expected to be a Groundwater Dependant Terrestrial Ecosystem.

A more detailed description of this habitat along with its expected sensitivity is described in **Chapter 11: Terrestrial Ecology**.

5.3.2.6 Surface Water Features (SWFs)

The surface water features identified within the study area and their respective sensitivities are detailed in **Chapter 9: Hydrology and Flood Risk Assessment Tables**.

5.3.3 Contaminated Land

5.3.3.1 Historical Information review

A review of the Envirocheck historic maps indicates that the Development Area remained undeveloped until 2001, when the maps record the presence of a sand and gravel pit within the Development Area boundary. It should be noted that the next earliest map is from 1966 and so development of quarrying activities cannot be accurately dated using these sources of information. No other development of the Development Area is able to be discerned from the available historical maps.

Consultation with Highland Council revealed that the site was granted planning permission on 1 May 1992 for sand / gravel extraction. The Phase I Environmental Due Diligence Report (Fairhurst, 2015) indicates, based on interviews with the previous site owner that the Development Area began to be used for the extraction of sands and gravels as an unlicensed facility from approximately 1974. Information provided by the previous site owner also indicated that a concrete block manufacturing facility was present from the mid-1970s in the area immediately east of the Development Area where a concrete surface slab remains. The Phase 1 recorded the presence of staining of the ground in the area around the location of a former diesel generator based on information gathered during a site walkover.

Highland Council reported a petrol filling station to be present approximately 330m to the east of the site, near Skye Bridge, but was discounted as a potential contaminated land source for the purpose of this assessment based upon its distance from the study area.

5.3.3.2 Pre-existing assessments

The Phase I Environmental Due Diligence Report (Fairhurst, 2015) consisted in a desk based review of the Development Area based on historic maps, site plans, a site walkover and consultations with statutory authorities in order to create an initial conceptual site model (CSM) which was used to inform the scope of an intrusive Phase II ground investigation for both geotechnical and environmental purposes.

Intrusive Phase II Ground Investigation was designed by Fairhurst and conducted by BAM Ritchies with the aim of testing the preliminary CSM and identifying potential abnormal geotechnical and geo-environmental constraints on the Development Area. The investigation comprised a series of non-targeted positions on a 20m-25m offset herringbone grid, as well as positions targeted to potential areas of contamination as identified during the Phase 1 Environmental Due Diligence Report. All positions were undertaken to investigate the potential pollutant linkages identified in the Preliminary Conceptual Site Model (CSM), with soil samples collected from each position. In order to fully assess the risk to groundwater and surface water at the Proposed Development, two rounds of water sampling were undertaken on the boreholes drilled as part of the investigation works. The locations of all exploratory positions are presented in **Figure 5.1**. Samples of soils and groundwater were collected and sent to Exova Ltd for chemical analysis.

The resultant data was then screened against generic assessment criteria (GAC), derived from various published standards, in order to put the data into context and form part of a risk assessment. This information was used to update the CSM and provide recommendations for further assessment. Detailed information regarding the Phase I and Phase II studies can be found in **Appendix 5.1**.

5.3.3.3 Identified Sources

Those sources deemed as posing a risk of moderate or above in the Phase II risk assessment were taken forward as potential sources and included in the following impact assessment.

These sources were:

- general made ground which was thought to be the source of various heavy metal, Polycyclic Aromatic Hydrocarbons (PAH) and Volatile Organic Compounds (VOC) exceedances detected across the site, and;
- a former diesel generator suspected as being the source of hydrocarbons noted in RBH10.

Peat was listed as a potential source of ground gas based upon a Photoionisation Detector (PID) reading of 0.1ppm. This is not viewed as a significant exceedance, and as there were no elevated carbon dioxide readings from the same position, peat as a contamination source has been discounted from the contaminated land impact assessment.

In addition, after review of the chemical analyses performed on the excavated sediment samples it was considered that the excavatedmaterial could pose a risk to the water environment. The high organic content present in the cores indicated that there could also be an issue with the production of soil gas and so the excavated material was taken forward as a source into the impact assessment.

The locations of identified contamination sources are shown on **Figure 5.1**.

5.3.3.4 Excavated Material Assessment

It is proposed that part of the excavated material be re-used on the western part of the site (**Figure 2.1**).

In order to determine whether the excavated material could pose a risk to on-site receptors, the results of the sediment analysis were compared against human health assessment criteria (Category 4 Screening Levels (C4SLs) and Suitable 4 Use Levels (S4ULs)). The rationale for the use of these standards is the same as that used in the Phase II risk assessment and is described in detail in **Appendix 5.1** and the results of the screening exercise are provided in **Appendix 5.3** and show that no exceedances of the human health criteria were found in the results from the sediment testing.

To assess the risks posed to the water environment a two tier process was undertaken. The first tier involved a comparison of the leachate chemical analysis was compared against SEPA published marine surface water Environmental Quality Standards (EQS) for the marine environment (SEPA Supporting Guidance document: WAT-SG-53, 2014). The marine EQS are considered the most appropriate surface water assessment criteria, as the principal receptor is considered to be the sea inner sound of Skye. The second tier involved the application of a 3.7 dilution factor to the original leachate concentrations with the resultant concentrations then compared against the marine EQS. The dilution factor was based upon estimates of total flow in the superficial aquifer and the volume of leachate derived from the infiltration of rainfall through the potentially contaminated excavated material. The first tier screening indicated that heavy metals: arsenic, cadmium, copper, lead and zinc in addition to free ammonia and phenol index (as C6H5OH) exceeded the marine EQS. The second tier screening indicated that the concentrations of these parameters did reduce; however, a number of parameters (arsenic, copper, zinc, free ammonia and phenol index) remained above the marine EQS with the majority only marginally so. The rationale for the use of these standards is the same as that used in the Phase II risk assessment and is described in detail in **Appendix 5.1**.

No exceedances of the human health criteria were found in the results from the sediment testing.

A dilution factor of 3.7 was applied to the leachate results based upon estimates of total flow in the superficial aquifer and the volume of leachate derived from the infiltration of rainfall through the potentially contaminated excavated material. This factor was applied to the chemical testing results of the excavated material and some exceedances of the EQS values for copper, zinc, arsenic, ammonia and the phenol index as C6H5OH were found. The results of the screening of chemical testing against assessment criteria are presented in Appendix 5.3.

The results provided in **Appendix 5.3** show that none of the exceedances of the marine EQS values are for Water Framework Directive (WFD) Priority Hazardous Substances (PHS). Detected exceedances are for WFD UK Specific Substances and as such there will further dilution of the leachate concentrations will take place when discharging to the sea, which will reduce the concentrations well below the marine EQS.

5.4 Predicted Impacts

The potential impacts of the Proposed Development are assessed prior to the implementation of mitigation. Potential mitigation are then identified and described in **Section 5.5 (Mitigation Measures)**.

There are a variety of ways in which the Proposed Development can impact on geological resources, as follows:

- excavating or masking exposures of bedrock or superficial geological deposits of specific scientific interest if the features of interest are not reproduced elsewhere in the area;
- constraint / limitation to existing or potential commercial exploitation of resources;
- effects on underlying groundwater aquifers, for example, through the dewatering of aquifers as a result of construction works involving excavation;
- risk of spillage or leakage of fuel or oil from storage tanks or construction plant, which without suitable mitigation measures, can enter aquifers; and
- effects of changes to groundwater flow or quality on secondary receptors such as groundwater abstractions, surface water or GWDTEs.

A key aspect of the impact assessment is to identify areas of proposed excavations. Information available at the time of writing this report suggest that the upper 0.5 – 1.0m of the subsurface would be removed to facilitate the construction works. It has therefore been assumed for the purposes of this assessment that 1.0m excavations will be constructed in the footprint of all buildings that comprise the Proposed Development. Piling is also expected to be widely used across the site, with up to 1600 tubular steel piles driven to an average depth of 16mbgl across the site.

5.4.1 Geology

5.4.1.1 Bedrock Geology

Minimum depth to bedrock is reported as 9mbgl within the study area and therefore no impacts are expected on bedrock geology due to removal of the upper 1m of the subsurface.

The proposed use of piling on site would impact on bedrock deposits and result in a decrease in their extent, which is considered to be of negligible magnitude. This results in a potential impact of Negligible significance for bedrock deposits during both the construction and operation phases.

5.4.1.2 Superficial Geology

Soil and superficial deposits are likely to be impacted by the excavations, piling and other earthworks during the construction of the Proposed Development. The reduction in the extent of these superficial deposits as a result of these construction activities is considered to be of negligible magnitude for all deposits, except peat, because of the widespread presence of these deposits elsewhere in the region and in the country. Excavation of peat is expected to be localised and minimal, estimated to be a volume of $10m^3$, generating a low magnitude of impact. This results in a potential impact of Negligible / Slight significance for peat and Negligible significance for all other superficial deposits.

5.4.1.3 Mineral Extraction

Exploitation of natural mineral resources has occurred within the study area up until very recently, and recoverable resources are still present in the Development Area. However, due to the relatively wide spread occurrence of these deposits within the local area, the impact magnitude of the construction of the Proposed Development is deemed to be negligible, resulting in a potential impact of Negligible significance.

5.4.2 Hydrogeology

5.4.2.1 Groundwater Flow

No impact on groundwater is expected as a result of the removal of the upper 1m of the ground surface, as these works are not expected to intercept groundwater.

The dense network of piles proposed as part of the construction of the Proposed Development is considered likely to impact groundwater flow patterns and could alter groundwater flow paths and raise groundwater levels

within both the superficial and bedrock deposits. The magnitude of these potential impacts has been assessed as having an impact magnitude of medium on both superficial and bedrock groundwater. This results in an overall impact significance of Slight / Moderate on bedrock groundwater and Negligible / Slight to Moderate on groundwater within superficial deposits.

The construction of embankments may result in localised compaction of superficial deposits. This would result in localised impacts of negligible magnitude for groundwater flow and has therefore been assessed as being of Negligible to Negligible / Slight significance on groundwater within the superficial deposits.

5.4.2.2 Groundwater Quality

In the event of accidental spillage during the construction or operational phases, potential contamination may migrate through the upper unsaturated zone reaching the shallow aquifer associated with superficial deposits and impair groundwater quality, unless appropriate measures for control of discharge and drainage are taken.

The potential magnitude of impact from accidental spillages is considered to be medium on shallow groundwater present in superficial deposits and low on bedrock. The potential impact assessment of accidental spillages on these aquifers is summarised in **Table 5.11**.

Table 5.11 : Potential Impact of Accidental Spillages on Key Hydrogeological Units During Both Construction and Operation Phases

Hydrogeological Unit	Sensitivity	Magnitude of Impact	Significance of Impact
Superficial – Made Ground	Negligible	Medium	Negligible / Slight
Superficial – Alluvium, Raised Marine Deposits, Marine Beach Deposits	Medium	Medium	Moderate
Superficial – Peat	Low	Medium	Slight / Moderate
Bedrock – Applecross Formation	Low	Low	Negligible / Slight

Potential impacts of accidental spillages on surface water features are discussed in **Chapter 9: Hydrology and Flood Risk Assessment Tables.**

As part of the Proposed Development, steel piles will be driven from the surface to circa 16mbgl. This could present a preferential pathway through which potential surface contamination, arising from activities such as vehicle washing or the storage and use of fuels, could reach the underlying superficial and bedrock aquifers. This has been assessed as having a magnitude of impact of medium resulting in a Negligible / Slight significance for bedrock groundwater and Negligible / Slight to Moderate significance for superficial groundwater.

5.4.2.3 Surface Water Features

Potential surface water quality impairment or reduction in baseflow contribution as a result of impact on the groundwater environment have been assessed based on the proximity of surface water features to areas where impacts on the groundwater environment could potentially occur. The shallow depth of the ground excavations proposed as part of the Proposed Development means that no impacts are expected on the surface water features identified within the study area.

Excavated material is to be deposited down gradient of the identified surface water features and therefore no impacts are expected on surface waters as a result.

5.4.3 Contaminated Land

A number of potential pollution sources, migration pathways and potential receptors that may be at risk as a result of the Proposed Development have been identified. Potential risks have been assessed where complete pollutant linkages have been identified between contamination sources and receptors.

There are two potential ways in which construction of the Proposed Development could impact contaminated land:

- direct disturbance of potentially contaminated land sites (i.e. sources are within the footprint of the Proposed Development); and
- indirect disturbance of potentially contaminated land sites as a result of construction of the Proposed Development (i.e. potential pathways which exist within the footprint).

5.4.3.1 Construction Phase - Direct Disturbance

Direct disturbance with a number of potentially contaminated land sources has the potential to impact on human receptors as summarised in **Table 5.12**.

Table 5.12 : Construction – Potential Direct Contaminated Land Impacts

Source	Pollutant Pathway	Magnitude	Likelihood	Significance
Made ground	PP1	medium	likely	Moderate
Made ground	PP2	severe	likely	High
Made ground	PP3	medium	low	Moderate / Low
Former diesel generator	PP1	medium	likely	Moderate
Former diesel generator	PP2	severe	likely	High
Former diesel generator	PP3	medium	low	Moderate / Low
Excavated material	PP2	severe	likely	High

5.4.3.2 Construction Phase - Indirect Disturbance

Indirect interaction of construction workers with potentially contaminative sources could occur if the steel piles create a preferential pathway for the migration of ground gases to the surface. The magnitude of this potential impact is assessed as severe, with a likelihood of low resulting in an overall significance of Moderate.

During the construction phase the deposition of excavated material on site could pose a risk to the water environment via PP5 and PP7. The assessment on water environment is focussed on the sea (as discussed in Section 5.3.3.3). This has been assessed as posing a magnitude of impact of minor with a likelihood of likely resulting in an overall impact significance of Low.

5.4.3.3 Operation Phase - Direct Disturbance

The same potentially contaminated land sources as shown in **Table 5.12** have the potential to be similarly directly disturbed during the operation phase as during the construction phase, but with a reduced likelihood, as summarised in **Table 5.13**. It should be noted that direct human interaction with contaminated soils would not be expected during the operation phase and has been discounted.

Table 5.13 : Operation – Potential Direct Contaminated Land Impacts

Source	Pollutant Pathway	Magnitude	Likelihood	Significance
Made ground	PP12	medium	low	Moderate / Low
Made ground	PP14	medium	unlikely	Low
Former diesel generator	PP12	medium	low	Moderate / Low
Former diesel generator	PP14	medium	unlikely	Low
Excavated material	PP14 & 16	severe	likely	High

5.4.3.4 Operation Phase - Indirect Disturbance

Indirect interaction of site operations and workers with potentially contaminative sources could occur if the steel piles create a preferential pathway for the migration of ground gases to the surface. The magnitude of this potential impact is assessed as severe, with a likelihood of low resulting in an overall significance of Moderate.

During the operation phase the deposition of excavated material on site could pose a risk to main water environmental receptor (the sea) via PP19. This has been assessed as posing an impact magnitude of minor with a likelihood of likely (which will reduce to unlikely over time) resulting in an overall impact significance of Low to Very Low.

5.5 Mitigation Measures

Mitigation measures are proposed based upon the findings of the already existing reports and based on the outcome of the pre-existing ground investigations. All future work should be undertaken in consultation with Highland Council and SEPA.

5.5.1 Geology

The disturbance of peat deposits will be kept to a minimum and their re-use on site, where possible, will be maximised. Peat excavation, storage, and any off-site removal required would be undertaken in accordance with 'Development on Peatland: Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and the Minimisation of Waste' (Scottish Renewables and SEPA 2012) and will comply with relevant waste management practices under The Waste Management Licensing (Scotland) Regulations 2011 (Scottish Government, 2011).

Impacts on all other geological deposits are considered to be of Negligible significance and so therefore mitigation measures are not required.

5.5.2 Hydrogeology

5.5.2.1 Groundwater Flow

Chapter 9: Hydrology and Flood Risk Assessment Tables provides details on anticipated mitigation to address potential impacts on surface waters, including adherence to SEPA Pollution Prevention Guidelines (PPGs) during construction, and appropriate road drainage and runoff treatment. These measures would also mitigate against water pollution risk to groundwater by reducing the potential for pollutant release and reducing the likelihood of any contaminated runoff produced by the works entering groundwater either directly or via the unsaturated zone. These mitigation measures would also protect groundwater receptors against impacts on water quality.

Groundwater level should be monitored prior to and during the construction and into the early operation phase to understand the magnitude of potential groundwater rise as a result of the piling works. A site drainage management plan should be developed to drain the site, including areas where groundwater level may reach the surface or become very shallow.

The contractor should conduct a Piling Risk Assessment, including a method statement for the installation of the piles and develop protocols to ensure risks to groundwater flows and quality are minimised.

5.5.3 Contaminated Land

Safe systems of work and use of personal protective equipment should be implemented to minimise contact by future construction and site workers with any potentially contaminated soil or groundwater.

General contaminated land mitigation measures should include:

- implementation of a watching brief during construction works to take account of the potential presence of previously unidentified contamination;
- vehicle washing, fuel storage and refuelling should be conducted in bunded areas to prevent runoff of contaminated water;
- storage of excavated made ground material using bunded facilities and development of re-use criteria to ensure suitability for inclusion within the Proposed Development;
- removal of contaminated soils from site if required taking into account the design and risk assessment;
- consolidation for treatment ex-situ if required to render material suitable for re-use or retention; and / or,
- treatment in situ (of soil and / or water) if required to render material suitable for re-use or retention;

Waste management procedures will include but not be limited to: Waste Management Licence Regulations 1994 (as amended by Waste Management Licensing Amendment (Scotland) Regulations 2012)) and HSE Guideline Note MS13 Asbestos 2005, the Health and Safety Commission Approved.

To protect the water environment, excavated made ground material will be stored using bunded facilities and re-use criteria – as part of a Material Management Plan - will be developed so as to mitigate any long term impacts.

Based on the information available at this stage, the excavated material appears to be chemically suitable for re-use on site. However, further chemical testing should be undertaken by the Contractor to verify this initial assessment priori to re-using the materials

5.5.4 Ground Gas and Vapours

A Ground Gas Defence System conforming to CIRIA C665 'Characteristic Situation 2' (CS2) (CIRIA, 2007) with a required Gas Protection Score of 2.5 (based upon Type C building in accordance with BS 8485:2015) is recommended in all new structures at the Proposed Development including basements. The Ground Gas Defence System should also include a membrane which is resistant to Hydrogen Sulphide and VOCs.

There are potential risks to construction workers from asphyxiation, in particular associated with below ground works or entry to confined spaces where ground gases can accumulate associated with the re-use of excavated materials on site. As such safe systems of work will need to be developed by the construction contractor to control all below ground works as applicable to confined space entry, including use of PPE as a last resort. For the operational phase, a Gas Risk Assessment will need to be undertaken by the Contractor to assess potential long term gas risks associated with excavated materials, in particular in relation to the nearby proposed buildings.

5.6 Residual Impacts

Residual impacts on geology are expected to be of Negligible significance.

A residual impact of moderate significance is expected on groundwater flow within the superficial deposits and a residual impact of slight / moderate significance is expected within the bedrock deposits.

The implementation of mitigation measures in relation to the protection of the water environment against pollution incident is expected to reduce the potential impacts on groundwater quality and associated receptors to a residual impact of Slight significance.

The implementation of mitigation measures in relation to contaminated land issues and direct / indirect impacts is expected to reduce potential impacts to a residual impact of Low significance during the construction and operational phases.

5.7 Cumulative Impacts and Impact Interrelations

There are no local developments that would pose a cumulative impact on the geology and hydrogeology of the site.

5.8 References

British Geological Survey (1995). BGS Groundwater Vulnerability Map of Scotland

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