Ardrossan North Shore
Site Investigation 2022, Interpretative Report

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CONTROL SHEET

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1 INTRODUCTION

In November 2022 North Ayrshire Council commissioned SKF Limited to carry out further intrusive site investigation work at the Ardrossan North Shore development site. The site is proposed for a mixed use development incorporating a school campus, residential housing with gardens and commercial land uses.

Previous site investigation works were undertaken at the site and reported in EnviroCentre Report No 8754, Ardrossan Development Site Investigation 2019 and 2020, Interpretative Report (December 2020) and EnviroCentre Report Coast to Coast Site Phase I and Phase II Interpretative Report (May 2021) the site. This report should be read in conjunction with these previous reports.

In addition to these more recent assessment EnviroCentre undertook a detailed delineation exercise on a northern portion of the site (at the time termed Phase I of the Ardrossan Development site) as reported in EnviroCentre Report No 3585 Delineation Investigation, Ardrossan Phase I (2008).

Following this 2008 investigation remedial works were undertaken in the northern area of the site, which were detailed in EnviroCentre Report No 4295, Close Down Report Ardrossan Phase I Site (August 2013).

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2 PURPOSE AND SCOPE OF 2022 SITE INVESTIGATION

The purpose of the 2022 site investigation was to provide additional information with respect to soil and groundwater chemistry with a particular focus on areas that were not fully assessed as part of the 2019 and 2020 site investigation works. The primary reason these areas were not accessed historically was presence of existing stockpiles of material.

The investigation design therefore allowed for access of plant adjacent to and on stockpiles to allow for sample recovery from existing ground located beneath the stockpiles.

The works incorporated the following intrusive locations:

- 32 Trialpits – EC1 to EC32.
- 19 Shell and Auger Boreholes – (ECBH1 to ECBH18 including ECBH14A).

The purpose of these intrusive locations was to target those areas for additional investigation and collect soil samples for subsequent laboratory analysis. In addition, soil samples were also collected from the existing stockpiles on site (formed as part of site remediation works undertaken in 2011) to provide further information on their chemical quality. The locations which targeted the stockpile material was ECBH1-ECBH12. In these locations samples from the top 3 metres are considered to be representative of the stockpile material, with samples below that taken from the ground present beneath the stockpiles.

In conjunction to the above scope of works some additional trial pitting was undertaken to provide further information on physical ground conditions and the revetment (note no chemical testing was undertaken and as such these are not discussed in detail in this report). These incorporated:

- 17 Trialpits – OBTP01 to OBTTP17
- 5 Trial Trenches – OBTR01 to OBTR05
- 10 Trialpits adjacent to the revetment – REVTP3 to REVTP12

In addition to summarising the findings of the 2022 investigation this report will also summarise information from the historic reports listed in Section 1 to provide an overall summary of the site investigation findings to date.

A site investigation plan detailing these locations and those undertaken as part of the 2019 and 2020 and Coast to Coast site investigation works is provided in Appendix A as 173958-GIS015. The plan also incorporates intrusive investigation points from the 2008 site investigation in EnviroCentre Report No 3585 Delineation Investigation, Ardrossan Phase I (2008). The plan details all the locations from the Delineation Investigation, note the majority of these were subsequently remediated as detailed in EnviroCentre Report no 4295.

The factual report for the 2022 site investigation (SKF Limited Ground Investigation Report, January 2023) is provided in Appendix B. This incorporates the intrusive location logs, monitoring results and the laboratory analysis certificates.

2.1 2022 Analytical Testing

A total of 192 soil samples were collected and analysed from the intrusive locations at various depths ranging from 0.2m to 4m below ground level throughout the existing ground profile. In addition

samples were also collected from existing stockpiles on site which were formed as part of remediation works in 2011 to allow for more information to characterise the stockpiles.

Soil samples were variously tested for the following analytes (which is the same suite utilised as part of the 2019 and 2020 investigation):

- Asbestos screen;
- pH;
- Total Organic Carbon (TOC);
- Metals/ metalloids – As, Cd, Cr , Cu, Pb, Hg, Ni, Se, and Zn;
- Fractionated Total Petroleum Hydrocarbons (TPH CWG);
- Volatile Organic Compounds (VOCs); and
- Semi-Volatile Organic Compounds (SVOCs, including Polycyclic Aromatic Hydrocarbons (PAHs)).

3 2022 SITE INVESTIGATION FINDINGS

3.1 Geology

The geology and hydrogeology encountered is detailed in the SKF Factual Report provided in Appendix B. A summary of the information is provided below.

3.1.1 Made Ground

Made ground was noted in the majority of investigation locations, generally formed of a soft brown gravelly clay or brown or grey gravelly clayey sand with angular to rounded gravel. Anthropogenic materials including ash, clinker bricks, wood and metal fragments were identified across the made ground.

3.1.2 Drift Deposits

Drift deposits principally comprised grey to dark grey silty fine to coarse sand containing shell fragments. Pockets of clay were noted in specific areas.

3.1.3 Bedrock

Bedrock was not proven during the investigation, however there were some locations where weathered sandstone was encountered (ECBH05 and ECBH18).

3.1.4 Groundwater

The boreholes recorded groundwater strikes in the existing ground at depths ranging from 2m to 4m below ground level. There was evidence of tidal influence on the groundwater within boreholes on the western portion of the site identified during the works.

3.1.5 Visual and Olfactory Evidence of Contamination

The majority of intrusive locations recorded presence of hydrocarbon odours or visual oil materials. Depths that these were encountered were generally at approximately 2m below ground level, however some locations recorded presence within the top metre.

4 ENVIRONMENTAL RISK ASSESSMENT

4.1 Human Health

For the purposes of the human health risk assessment, the soil sample results were screened against generic assessment criteria (GACs) for a residential with plant uptake land use scenario. It is considered that this screening criteria is appropriately conservative for assessment of the results in relation to the proposed mixed use development. The following section discusses the 2022 results in detail. The results from the 2019 and 2020 site investigation, the Coast to Coast investigation and the 2008 locations which were not addressed as part of the historic remediation have also been screened against the same criteria (summary tables are provided in Appendix D) with the findings detailed in the drawings referenced within the following sections.

Where available, the assessment criteria comprised the LQM/CIEH "Suitable 4 Use Levels" (S4ULs). These are recognised industry standard assessment criteria and are based on a minimal or tolerable level of risk, and as such are deemed to be suitably conservative for this initial generic screening assessment.

For lead, a DEFRA "Category 4 Screening Level" (C4SL) was used due to the lack of current alternative criteria. Unlike the other GACs used, which are based on a "minimal or tolerable level of risk", C4SLs are based on a "low level of toxicological concern". This means that they represent a lower standard of protection. Although considered to be appropriate for use as screening criteria in a Part 2A context (the statutory designation of contaminated land), the applicability of C4SLs with regard to planning is currently unresolved. At this stage however it is considered that these values be adopted to screen the results.

For the purposes of the assessment the criteria utilised was based on a 2.5% organic matter content (with the exception of metals for which organic matter is not a sensitive parameter for generation of the criteria and therefore is based on a default of 6%), which reflects the general concentrations recorded from site investigation works on the site.

It is noted in relation to asbestos that there is no specific GAC, and therefore this is considered separately initially on the basis of a presence/non presence risk.

A summary table detailing the findings of the screening assessment for human health is provided in Appendix C and discussed below.

4.2 Asbestos

Asbestos was identified within 16 of the 192 samples tested. The asbestos form identified incorporated a range of types including amosite, chrysotile and crocidolite. Quantification of the asbestos was undertaken with results provided in the SKF Factual Report in Appendix B.

The majority of asbestos was identified within the top metre of the site, which is deemed to be the soil profile of risk of generation of dust and therefore potential for asbestos exposure as part of the proposed development. There was asbestos identified up to depths of 4m in specific areas, which will require to be considered as part of any construction works involving excavation to depth.

Figure 173958-GIS017 in Appendix A details the locations of the asbestos identification for the 2022 investigation, the 2019 and 2020 investigation, the Coast to Coast investigation and the locations from the 2008 investigation which were not remediated at that time.

It is noted that none of the stockpile material samples from the 2022 investigation recorded presence of asbestos.

4.3 Risk Assessment Utilising Screening Criteria

A summary table of the 2022 lab results compared against the screening criteria is provided in Appendix C. Summary tables for the other site investigations are provided in Appendix D (note the 2008 assessment focuses solely on the areas that were not covered by the remedial works detailed in Report No 4295). The findings of the screening are summarised below.

4.3.1 Metals/Metalloids

For the 2022 results the majority of metal/metalloid analytes did not exceed the screening assessment criteria, with the exception of arsenic, lead and nickel.

- A total of 5 of the 192 samples analysed recorded slight exceedances of the residential arsenic criteria.
- 4 of the 192 samples recorded nickel concentrations in excess of the screening criteria, 2 out of 4 of these samples were located within the upper metre of the soil profile.
- 18 of the 192 samples recorded concentrations of lead in excess of the screening criteria. The samples depths ranged from within the top metre to up to 4m depth.
- None of the samples collected from the stockpile material recorded exceedances of the metal screening criteria.

Figure 173958-GIS018 in Appendix A details the locations of the metal exceedances with respect to the screening criteria. This figure details all locations recorded from the 2019 and 2020 investigation, the 2022 investigation, the Coast to Coast investigation and those remaining areas from the 2008 investigation (still present post remedial works). Sample exceedances were recorded in the upper metre of the soil profile, which is deemed to be the critical depth with respect to the pathways to receptors from these contaminants (ingestion and direct contact with soil and inhalation of dust).

4.3.2 TPH

A total of 7 of the 192 2022 soil samples analysed recorded exceedances for specific TPH carbon band fractions. None of the samples from the stockpile material recorded exceedances of the TPH criteria. The fractions that recorded exceedances included:

- Aliphatic TPH C8-C10 (3 samples recorded exceedances);
- Aliphatic TPH C10-12 (2 samples recorded exceedances);
- Aliphatic TPH C12-C16 (1 sample recorded exceedances);
- Aromatic TPH C12-C16 (4 samples recorded exceedances);
- Aromatic TPH C16-C21 (6 samples recorded exceedances);
- Aromatic TPH C21-C35 (1 sample recorded exceedances);

With respect to the TPH fractions that recorded exceedances the following is noted:

Aliphatic TPH C8-C10

Under the screening criteria the relevant exposure pathway for this TPH fraction is inhalation of vapours (indoors) which contributes 49.4% of the contribution to exposure. The remainder of the

exposure pathway contribution is principally formed from inhalation of background concentrations (i.e. exposure to this contaminant from other daily exposure routes - 49.4%) and ingestion of soil and indoor dust (0.4%). On this basis the critical pathway of concern for the site is release of vapours into any proposed buildings.

Aliphatic TPH C10-C12

As for Aliphatic TPH C8-C10, the principal contribution pathway for Aliphatic C10-C12 is indoor vapour inhalation (forming 48% of exposure) with the remainder coming from inhalation of other background sources from daily activity (48%) and a higher contribution from ingestion of soil and indoor dust on the site (1.9%).

Aliphatic TPH C12-C16

Aliphatic TPH C12-C16 is similar in nature to the other 2 aliphatic fractions, however the contribution from indoor vapour inhalation and inhalation of background sources forms a slightly smaller contribution as a relevant pathway (36.7%) with ingestion of soil and indoor dust forming a larger contribution (12.5%) and some minor contribution from dermal contact indoor and outdoor (0.2% and 0.3%).

On this basis whilst the indoor inhalation of vapours is the primary pathway of concern, there is a stronger requirement to address the potential ingestion of soils and indoor dust.

Aromatic TPH C12-C16

For Aromatic TPH C10-C12 inhalation of indoor vapour contributes 2.8% as a relevant pathway, with background exposure to oral exposure and inhalation of vapours forming 2.8% and 47.2% of the relevant pathway contribution respectively. For the aromatic fractions ingestion of soil and indoor dust for 11.7% of the relevant pathway contribution with consumption of homegrown produce and attached soil comprising 34.9% of the contribution to total exposure. There is some minor contribution from dermal contact indoor and outdoor, 0.2% and 0.3% respectively.

Aromatic TPH C16-C21

For this fraction the principal relevant pathway contribution is via ingestion of soil and indoor dust (23.1%) and consumption of homegrown produce and attached soil (25.7%). 50% of the contribution coming from background exposure through an oral route. This fraction has very limited contribution from indoor vapour inhalation (0.2%) whilst indoor and outdoor dermal contact pathways have an increased contribution of 0.4% and 0.6% respectively.

Aromatic TPH C21-C35

For this fraction the principal relevant pathway contribution is via ingestion of soil and indoor dust (42.3%) and consumption of homegrown produce and attached soil (5.8%). 50% of the contribution coming from background exposure through an oral route. This fraction has no contribution from indoor vapour inhalation whilst indoor and outdoor dermal contact pathways have an increased contribution of 0.8% and 1.1% respectively.

The majority of the TPH exceedances have been recorded at depths of 2m below ground or greater, however given that vapour release is a key parameter the risks from these elevations is relevant. There are also exceedances of aromatic compounds within the top metre of the site which present an ingestion and inhalation risk.

Figure 173958-GIS019 in Appendix A details the areas where TPH elevations have been recorded. As above this incorporates the 2022 investigation, the 2019 and 2020 investigations and the areas from 2008 which were not remediated at that time.

4.3.3 Volatile Organic Compounds (VOCs)

The majority of the 2022 samples did not record concentrations of VOCs above the laboratory detection limits, where compounds were identified they did not exceed the screening assessment criteria.

4.3.4 Semi-Volatile Organic Compounds (SVOCs)

The majority of SVOCs from the 2022 samples did not record exceedances in relation to the screening criteria, however specific Polyaromatic Hydrocarbon (PAH) compounds were elevated above the assessment criteria including:

- Naphthalene (3 samples out of 192);
- Benzo(a)anthracene (3 samples out of 192);
- Chrysene (2 samples out of 192);
- Benzo(b)fluoranthene (9 samples out of 192);
- Benzo(a)pyrene (9 samples out of 192);
- Indeno(1,2,3-cd)pyrene (1 sample out of 192);
- Dibenz(a,h)anthracene (9 sample out of 192).

For the majority of these PAHs the pathway of concern is ingestion of soil and indoor dust, with the exception of naphthalene which also poses an indoor vapour risk. None of the stockpile material samples recorded exceedances of the PAH screening criteria.

A plan showing the location of the PAH exceedances (again representing all the previously noted investigation findings) is provided as Figure 173958-GIS020 in Appendix A.

4.4 Human Health Risk Assessment Discussion

The Human Health Risk Assessment has adopted generic criteria developed for a residential with plant uptake land uses scenario.

On the basis of the RES assessment the following significant Source-Pathway-Receptor (SPR) linkages were identified:

- Impact to Human Health from TPH Fractions and PAHs Via Inhalation of indoor vapours
- Impact to Human Health from TPH Fractions, PAHs and Heavy Metals via ingestion of soil and domestically grown produce, inhalation of indoor dust and indoor and outdoor dermal contact.
- Impact to Human Health from inhalation of asbestos.

Regarding the human health issues identified, there are potential applicable remedial measures that would be sufficient in breaking the pathways in the SPR linkages, this would incorporate:

- Provision of a suitable environmental cap across the open areas of the site to break the direct contact/ingestion and dust generation pathway.
- Provision of appropriate vapour mitigation measures within buildings to break the potential for release of volatile contaminants into the building.

- Provision of appropriate ground gas mitigation measures.

In addition to the above mechanisms, intrusive remedial measures for soils and groundwater in specific areas of the site would also be employed.

It is noted that the soil samples taken from the existing stockpiles present on site did not record any exceedances of the human health assessment criteria. This provides further information (particularly in relation to material near to the base of the stockpiles) which builds on the findings of EnviroCentre Report No 9464 Ardrossan North Shore Stockpile Assessment (February 2021).

4.5 Ground Gas Assessment

The gas risk assessment was undertaken in line with the semi-quantitative methodology given in BS 8485:2015+A1:2019. The results of the gas monitoring can be utilised to provide an estimate of risk for the site in relation to ground gas generation and accumulation.

The site can be characterised based on gas concentrations and borehole flow rates. The maximum concentrations and flow rate recorded for each monitoring location are detailed in Table 4-1 and have been used to derive gas screening values (GSVs). The overall risk classification for the site is, however, derived using the maximum recorded gas concentration and flow rate from all locations. As part of this assessment data from the 2019 and 2020 have also been included to identify the maximum values recorded over all monitoring rounds carried out at the site (in this case a flow rate from the 2019 and 2020 data of 1l/hr has been brought into this assessment as this is higher than recorded in the 2022 monitoring). This represents a reasonable worst-case scenario and is considered to be appropriate due to the acute nature of human health effects related to ground gas generation.

Table 4-1: Determination of Gas Screening Values (GSVs) and Site Characterisation

Borehole Number	Max. BH Flow Rate (L/hr)	Max. Gas Concentration		Gas Screening Value (GSV)[1] (L/hr)	Risk Classification[2]
		CH_4 (% v/v)	CO_2 (% v/v)		
ECBH1	0.1	2.2	12.5	0.0125	
ECBH2	0.1	5.6	13.6	0.0136	
ECBH3	0.1	6.4	14.4	0.0144	
ECBH4	0.2	2.5	14.1	0.0282	
ECBH5	0.3	0.8	11.8	0.0354	
ECBH6	0.2	2.0	9.1	0.0182	
ECBH7	0.2	1.1	8.9	0.0178	
ECBH8	0.1	13.7	12.7	0.0137	
ECBH9	0.2	13.7	10.6	0.0274	
ECBH10	0.1	5.8	10.6	0.0106	

ECBH11	0.1	1.3	10.7	0.0107	
ECBH12	0.2	0.3	10.2	0.0204	
ECBH13	0.1	0.6	8.1	0.0081	
ECBH15	0.1	0.2	7.4	0.0074	
ECBH16	0.1	0.1	8.3	0.0083	
ECBH17	0.1	0.1	4.0	0.004	
ECBH18	0.1	3.9	9.5	0.0095	
ALL BOREHOLES	**1.0**	**13.7**	**14.4**	**0.144**	Gas Characteristic Situation 3: Moderate Hazard Potential

GSV = max. measured concentration (CH_4 or CO_2)/100 x max. measured borehole flow rate. Where a maximum flow rate of 0 was obtained, a conservative flow of 0.1L/hr was used in the calculation.

BS 8485:2015+A1:2019: CS1 if GSV <0.07L/hr, CS2 if GSV is 0.07 – <0.7L/hr, CS3 if GSV is 0.7 – <3.5L/hr.

The site investigation identified potential sources of ground gas generation including presence of hydrocarbons in soil and groundwater and organic materials present in made ground.

Previous assessment has identified tidal influence of the groundwater on the seaward side of the old seawall, no significant evidence of tidal influence on the landward side. Tidal fluctuation may have an impact on ground generation and migration. The foundation solution for the site is not detailed at the time of reporting but will likely incorporate a piled solution which may provide a preferential pathway for gas migration. This should be considered as part of the detailed design work for the site.

The principal pathways of concern will be via migration into the proposed buildings in the site, either through cracks in the solumn or service runs. Given the site has a made ground coverage then there could be a variety of preferential pathways.

Further to the monitoring works undertaken during the site investigations a detailed assessment of ground gas risk was undertaken by Ground Gas Solutions in June 2023. The works incorporated a continuous gas monitoring assessment to provide a more detailed level of assessment than the spot monitoring carried out as part of the original site investigation scope. A copy of the report is provided in Appendix E.

The assessment concluded that:

The worst case assessment of the evidence collected indicates that the site should be categorised as Characteristic Situation 1 (CS1), however, given the potential for carbon dioxide concentrations to be particularly elevated, it is considered that no special ground gas protection measures would be inadequately protective. As such, it is considered necessary that the worst case characteristic situation be uprated to Characteristic Situation 2 (CS2).

Where membrane-based protection measures are selected, these should give consideration to the residual risk posed by volatile organic compounds in addition to the bulk gases directly measured. By contrast, surface emissions results indicate the risk at surface is very low (commensurate with CS1). In assessing a final classification for the site as a whole, it is necessary to consider the scale of the

residual hazard, along with the practical differences afforded in the gas protection standards dictated by differing characteristic situations. In considering the worst credible case, whereby an unsealed pathway is left in-situ or created directly beneath the proposed school building, the conditions for an unacceptable pollutant linkage clearly exist. Bearing this in mind, it is considered that a blanket CS1 classification (i.e. no special precautions) would be insufficiently conservative. As such, it is considered that a classification of CS2 is appropriate.

All available lines of evidence indicate a low to moderate ground gas risk, commensurate with Characteristic Situation 2. Special gas protection measures are considered necessary within the proposed school building, however, ongoing consideration to the revised conceptual site model should be made during detailed design. Incorporating a pressure relief pathway within the final gas protection design should be considered to allow any ground gas concentrations present to safely dissipate, and to prevent the observed CO2 concentrations becoming widespread across the future building footprint.

On the basis of the continuous monitoring assessment undertaken by Ground Gas solutions a classification of Gas Characteristic Situation 2 has been identified for the site

In line with BS 8485:2015+A1 2019 the building on site is considered to incorporate both Type A and Type B building areas..

On the basis of the site being Characteristic Situation 2 with a Type A building then this would require a 3.5 minimum gas protection measure score.

Buildings associated with the Campus are considered to fall under a Type B Building type, as detailed in the British Standard as:

Type B building: private or commercial property with central building management control of any alterations to the building or its uses but limited or no central building management control of the maintenance of the building, including the gas protection measures. Multiple occupancy. Small to medium size rooms with passive ventilation of rooms and other internal spaces throughout ground floor and basement areas. May be conventional building or civil engineering construction. Examples include managed apartments, multiple occupancy offices, some retail premises and parts of some public buildings (such as schools, hospitals, leisure centres) and parts of hotels. A Type B building would also require a 3.5 protection measure with respect to the Gas Characteristic Situation 2.

As part of the design for future building developments on site appropriate protection measures should be adopted.

Potential options for protection could include:

Provision of an appropriately specified gas membrane with all penetrations sealed and designed to remain durable during the use of the building will provide a score of 2.

In addition, provision of a very good passive sub floor dispersal layer beneath the buildings (i.e. clear void or no fines gravel layer with gas drains) will provide a score ranging from 1.5 to 2.5.

It is understood that the school campus design will incorporate below ground structures including service rooms and a swimming pool. With respect the bulk ground gas risk to these structures the rating of Gas Characteristic Situation 2 is considered to be appropriate.

The gas mitigation measures associated with the below ground structures should be appropriately considered as part of their design.

As an example basement floor and walls conforming to BS 8102:2009, Grade 2 waterproofing would provide a score of 2 (The score is conditional on the waterproofing being provided by a suitable structural barrier with the design and detailing of the walls and floor meeting the requirements for Type B protection. The score cannot be assigned for Type A (waterproof membrane) or Type C (drained cavity wall). If a membrane is installed beneath and around the basement to provide Type A waterproofing (BS 8102:2009), it can be assigned a gas protection score in accordance with Table 7 (BS8485), if it meets all the criteria for a gas resistant membrane in that table.)

The design for future development should take into account the identified ground gas characterisation with mitigation measures suitably designed in line with BS 8485:2015+A1 2019. As detailed within BS 8485, once the design measures have been selected, these should be developed into a detailed design supported by detailed drawings and specifications. The detailed design should then be described in a design report.

4.6 Water Environment Risk Assessment

As detailed in the 2019 and 2020 interpretative report the principal risk to water environment at the site relates to the presence of TPH and in particular light non aqueous phase free product present on groundwater representing a source zone for ongoing potential impact.

The 2022 investigation incorporated a total of 6 groundwater monitoring rounds with each location being assessed with an oil interface probe to establish presence of free product.

In addition to this, to assess for the potential risk of ongoing impact to groundwater soil results have been screened against TPH and indicator parameter compounds in line with the assessment utilised as part of the remediation specification

4.7 Free Phase Product

Free phase product was not identified within any of the boreholes installed and monitored during the 2022 investigation.

Four boreholes did record some slight oil residue on the interface probe (ECBH08, ECBH09, ECBH10 and ECBH11) with ECBH11 also recording a strong hydrocarbon odour.

Figure 171301-015 details those areas that were identified as recording free product as part of the 2019 and 2020 site investigation.

4.8 Soil Results Assessment

As detailed within EnviroCentre Report No 9169, to assess the potential for TPH concentrations within soil to impact the Water Environment a total TPH concentration threshold of 1,000mg/kg (threshold value for hazardous material) has been applied.

In addition, in line with the approach detailed in report No 9169, indicator compounds have also been assessed to consider the potential for more mobile fraction of hydrocarbons to be present that may pose impact to the water environment below this threshold value. The parameters and values selected follow on from what was utilised as part of the 2019 and 2020 assessment and are summarised in the table below.

Table 4-2 Indicator Parameter Assessment Criteria

TPH Fraction	Indicator Parameter	Assessment Criteria
Aromatic EC8-10	Ethylbenzene	0.01mg/kg
Aromatic EC10-12	Naphthalene	0.5mg/kg
Aromatic EC12-16	Acenaphthylene	0.5mg/kg

The assessment identifies the following exceedances:

- 20 of 192 samples exceeded the total TPH screening criteria of 1000mg/kg.
- 24 of 192 samples exceeded the naphthalene screening criteria of 0.5mg/kg.
- 1 of 192 sample exceeded the acenaphthylene screening criteria of 0.5mg/kg.

A plan detailing the locations that exceeded the screening criteria (for the 2022 investigation, the 2019 and 2020 investigation, the Coast to Coast site and the areas that were not remediated following the 2008 investigation) 173958-GIS021 is provided in Appendix A.

4.9 Water Environment Risk Summary

The findings of the additional intrusive investigation works support the findings of the 2019 and 2020 investigation with no evidence of free product being identified on groundwater within boreholes located to the seaward side of the old sea wall which runs through the site.

Review of soil results have identified some areas of soil that will require intrusive remedial works to suitably address the potential for ongoing release of contaminants of concern to the water environment.

4.10 Conceptual Model

The 2022 assessment findings are not considered to alter the conceptual model that was developed for the site following the 2019 and 2020 site investigation, therefore the general conceptual model presented in Report No 8754 is still considered appropriate for the site.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

EnviroCentre have produced this interpretative report with respect to geo-environmental site investigations undertake at the Ardrossan Development site in 2022. The works build on previous investigation work undertaken in 2019 and 2020, 2021 Coast to Coast site and 2008 site investigation works and were primarily targeted to areas that had limited assessment as part of these previous investigations to fill the existing data gaps.

The intrusive works were designed by EnviroCentre and undertaken by SKF Limited.

The investigation design was produced in line with a Detailed Investigation scope as defined in BS10175: 2011+A2 2017 ('Investigation of Potentially Contaminated Sites'). and incorporated excavation of 32 trial pits and drilling and installation of 19 shell and auger boreholes. A total of 192 samples were collected from the intrusive locations and analysed for contaminants of concern relevant to the historic use.

The report has incorporated assessment of the analytical results against generic assessment criteria for human health risks. As part of this assessment results from historic SI information has also been reviewed and the data incorporated into the summary drawings detailing areas of identified contaminants of concern.

The assessment identified discrete areas where asbestos was present, this is considered to present a potential risk via inhalation of dust.

With respect to the "residential with plant uptake" land use scenario assessment elevated concentrations of heavy metals, speciated petroleum hydrocarbons and polyaromatic hydrocarbons were identified, areas of concern are detailed in Figures provided in Appendix A. On this basis the following significant source-pathway-receptor linkages are identified:

- Impact to Human Health from TPH Fractions and PAHs Via Inhalation of indoor vapours
- Impact to Human Health from TPH Fractions, PAHs and Heavy Metals via ingestion of soil and domestic produce, inhalation of indoor dust and indoor and outdoor dermal contact.
- Impact to Human Health via inhalation of asbestos.
- Impact to Human Health via inhalation/exposure to ground gases (note that the 2022 monitoring results have resulted in the site being reclassified as Characteristic Situation 2.

In addition to human health risks there were also the following identified risks to the water environment and future property:

- Impact to groundwater from free product;
- Impact to groundwater via leaching from soil;
- Impact to surface water via migration of contaminated groundwater.
- Impact to buildings from ground gases.
- Impact to building foundations and structures from aggressive ground conditions.

Based on the site investigation findings, remedial measures will require to be employed at the site as part of the proposed redevelopment.

5.2 Recommendations

A UKWIR assessment will be required once potential routes of water supply pipes is confirmed.

The design of all future buildings for the site should take have appropriate gas mitigation measures to address the ground gas characteristic situation 2 level that has been identified for the site. These measures should also be designed to restrict potential for volatile organic compounds to enter into structures.

The remedial specification (EnviroCentre Report No 9169) for the site will be updated to incorporate the information obtained from this additional investigation.

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