

Smithfield, Scoldhall Lane, Surfleet, Spalding, Lincolnshire

Phase 2 Ground Investigation Report

Report on behalf of Kirk Homes Limited

May2022

Final Report

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EXECUTIVE SUMMARY

Purpose of This Report	Phase 2 Ground Investigation Report
Client	Survey Hub Limited
Site	Smithfield, Scoldhall Lane, Surfleet, Spalding, Lincolnshire, PE11 4BJ
Site Location	The site is located off Scoldhall Lane in Surfleet, Lincolnshire, approximately 4.4km north-east of the town of Pinchbeck, and 6km north of Spalding. The site comprises a rectangular shaped parcel of land aligned north-east to south-west, and occupying an approximate area of 0.41 hectares (4,100m²). The approximate National Grid Reference is 526500, 329400.
Current Land Use	At the time of writing, the western and southern sections of the site were occupied by open ground. Most of this area comprised rough unmanaged shrubby grassland. Towards the north-east of the site was a single-storey agricultural building with a roof of cement sheet construction. The roof was damaged in several locations and had collapsed entirely towards the centre of the building. An external concrete slab occupied the east of the site adjacent to Scoldhall Lane. South of the building, situated on and adjacent to the concrete yard were piles of waste metal, rubber, ceramic, concrete and timber. A stockpile of soil, gravel and cobbles was also noted in this area. A larger heavily vegetated stockpile was recorded further west, close to the building. Due to the nature of the vegetation, the material within this stockpile could not be examined.
Proposed Development	Development proposals include the demolition of all site structures and the construction of two new structures across the northern and southern sections of the site which will form a contractor's yard / office, and a storage unit for the nearby Farm Shop. Vehicle parking areas and access roads will be constructed across the east and centre of the site using permeable paving. An exterior gravel yard areas will be constructed across the western and south-western sections.
Published Geology	The British Geological Survey (BGS) indicates the site is underlain by superficial Tidal Flat Deposits. These materials are typically soft silty clay with subordinate layers of sand, gravel, and peat. The site bedrock is recorded to comprise mudstone from the Oxford Clay Formation. Locally these deposits are typically described as grey silica rich mudstones with sporadic beds of limestone nodules. The site is within a Lower Probability Radon Area (with less than 1% of homes estimated to be at or above the Action Level). Basic radon protection measures are therefore required in the construction of new homes or buildings in this area.
Phase 1 Desk Study Recommendations	A Phase 1 Desk Study Report was produced for the site by Grange GeoConsulting Ltd in November 2021. It concluded that based on historical and current activities and site use, the risk from land contamination at the site was **Low** with respect to most potential sources identified. However, a **Moderate** risk was identified with respect to the presence of stockpiles of unknown provenance on-site. It was recommended that a nominal ground investigation be undertaken to examine this potential linkage of concern. This would involve the further investigation, logging, and sampling of on-site stockpiles to identify their chemical characteristics, and the presence of associated contamination. Due to the potentially poor geotechnical competence of the Tidal Flat Deposits, a geotechnical site investigation was recommended to support the scheme. Whilst not essential, it was recommended that during any such investigation, samples be collected for laboratory chemical analysis to confirm the contaminative status of soils and groundwater at the site. In addition, further

	examination of the ground gas generation potential, and the likely permeability of the Tidal Flat Deposits underlying the site was recommended.
Overview of Intrusive Works	The ground investigation undertaken at the site in March 2022 was based on the above recommendations and comprised: • The excavation of 5 No. window sample boreholes to a maximum depth of 3m below ground level (bgl) with dynamic probing within two locations (WS2 and WS4) and the installation of one groundwater and ground gas monitoring well (WS3) with subsequent precautionary monitoring; • The excavation of 2 No. hand pits within stockpiles identified during the Phase 1 Desk Study (HP1 and HP2); and • The collection of samples for geotechnical and chemical analysis and in-situ testing.
Findings of the Ground Investigation	<u>Made Ground</u> Brown, silty, slightly sandy clay and clayey or gravelly sand with concrete and quartzite. Rare ash noted in upper 0.1m in HP1 (Stockpile). <u>Topsoil</u> Dark brown, sandy Silt. <u>Tidal Flat Deposits</u> Loose to very loose, light brown, brown, yellow brown, orange and grey mottled, clayey, silty sand, and clayey sand. <u>Visual and Olfactory Evidence of Contamination</u> Rare ash was encountered in the upper 0.1m in HP1 in the location of the bonfire. No further visual or olfactory evidence of contamination was noted in either soils or groundwater. <u>Groundwater</u> Groundwater was recorded in the window sample boreholes twenty minutes following the completion of the drilling on site. Groundwater depths recorded within the Tidal Flat Deposits were 1.2m bgl (WS2 and WS5), 1.25m bgl (WS1) and 1.3m bgl (WS3 and WS4). A subsequent groundwater monitoring visit undertaken on 17th March 2022 recorded groundwater at a depth of 1.4m bgl in WS3.
Contamination Testing Results	<u>Soils</u> Laboratory analysis results of samples taken from the Stockpile at HP1 proved concentrations of a number of Furan and Dioxin congeners. The concentrations recorded, however, were not considered to represent a significant risk to the proposed development. A sample taken from WS1 at a depth of 0.1m bgl proved trace concentrations of several pesticide compounds; DDD-p-p, DDE-p-p, DDT-p-p, and Pendimethalin. The trace concentrations of pesticides identified during the investigation were not considered to represent a significant risk to the proposed development. No additional organic or inorganic contamination sources were identified during Site Investigation.
Geo-environmental Recommendations	Whilst no specific remedial/mitigation works are considered necessary at this stage, several recommendations have been made, which if implemented would further reduce associated risk: • It is recommended that construction/earthworkers use appropriate PPE and RPE, and that an appropriate safe working plan is established by the relevant contractors prior to commencement of works.

	• A watching brief should be maintained for contamination throughout the duration of the proposed development. In the event that any unforeseen gross or widespread contamination is encountered on site, an appropriately qualified contaminated land specialist should be contacted. • Any unexpected contamination encountered during the development should be subject to appropriate management. • Specialist contractors should be employed as necessary to advise on the management of unexpected contamination.
Geotechnical Recommendations	Made Ground will not be suitable as a foundation stratum due to its inherent variability and risk of intolerable differential settlement. The Tidal Flat Deposits could be suitable as a founding stratum for the proposed development using strip or trench fill foundations, depending on required loadings. Where strip and trench fill foundations are required within the low density predominantly granular materials of the Tidal Flat Deposits an allowable bearing capacity of 60kPa may be possible at depths of 0.5m bgl. Should the anticipated structural loadings exceed the allowable bearing pressures given above, alternative foundation options such as ground improvement and piles should be considered. It is recommended for preliminary design purposes a CBR value of 0.2% is adopted where formation level is within the natural Tidal Flat deposits. Based on guidelines provided in BRE Special Digest 1, the Tidal Flat Deposits underlying the site may be classified as Design Sulfate Class DS-1 and ACEC Class AC-1.

This Executive Summary forms part of Grange GeoConsulting Limited report number R21071/002 (Issue 1) and should not be used as a separate document.

1.0 INTRODUCTION

1.1 Terms of Reference

Consideration is being given by the Client, Kirk Homes Limited, to undertake redevelopment of a site known as Smithfield, located off Scoldhall Lane in Surfleet, Lincolnshire, approximately 4.4km north-east of the town of Pinchbeck, and 6km north of Spalding. The postcode for the site is PE11 4BJ, and the approximate National Grid Reference is 526500, 329400. A Site Location Plan (Drawing R21071-DWG1) is presented in Appendix A.

The site comprises a rectangular shaped parcel of land (hereafter referred to as the site in this report) aligned north-east to south-west and occupying an approximate area of 0.41 hectares (4,100m^2).

At the time of the investigation, the western and southern sections of the site comprised open ground which formed part of a field, extending off site to the west. A series of structures used for the storage of farming equipment and supplies were present towards the north and west of the site. Towards the west of the site was a concrete yard with vehicular access from Scoldhall Lane. A small area of open grassland was present towards the south-eastern corner of the site adjacent to Scoldhall Lane.

The area surrounding the site is predominantly rural. The areas to the north, west and east (beyond Scoldhall Lane) of the site are occupied by agricultural fields. South of the site is a residential property, with an associated garden area, beyond which is Spalding Farm Shop and Seasonal Plant Centre. A small car park associated with this facility is present to the rear (west), approximately 60m south-west. Both the residential property and farm shop open onto Scoldhall Lane.

Development proposals include the demolition of all existing structures, the removal of existing concrete hardstanding and the construction of two new 1-2-storey structures across the northern and southern sections of the site which will form a contractor's yard / office, and a storage unit for the nearby Farm Shop. In addition, vehicle parking areas and access roads will be constructed using permeable paving, and exterior yard areas (underlain by gravel) will be constructed across the western and south-western sections. A planning application (planning reference: H17-0005-21) was submitted for this development to South Holland District Council and was granted, subject to conditions, on 29th March 2021.

This report summarises the findings of a Phase 2 Ground Investigation that was undertaken at the site in May 2022, by Grange GeoConsulting Ltd. The report has been produced with the benefit of a Desk Study, produced as a standalone document by Grange GeoConsulting (Report Ref.R21071/R001), which should be read in conjunction with this report. A summary of the findings of the Phase 1 Desk Study are presented in Section 1.2.

1.2 Phase 1 Desk Study Findings

A Phase 1 Desk Study Report (report reference: R21071/001 Issue 1) was produced for the site by Grange GeoConsulting Ltd in November 2021. The Desk Study concluded that based on historical and current activities and site use, the risk from land contamination at the site was **Low** with respect to most potential sources identified. However, a **Moderate** risk was identified with respect to the presence of stockpiles of unknown provenance which were recorded on site during a site walkover undertaken in October 2021 by Grange GeoConsulting Ltd. It was recommended that a ground investigation be undertaken on site to examine this potential linkage of concern. This would involve the further investigation, logging, and sampling of on-site stockpiles to identify their chemical characteristics, and the presence of associated contamination.

Due to the potentially poor geotechnical competence of the Tidal Flat Deposits, a geotechnical site investigation was recommended to support the proposed scheme.

Whilst not essential, it was recommended that during any such investigation, samples be collected for laboratory chemical analysis to confirm the contaminative status of soils and groundwater at the site. In addition, further examination of the ground gas generation potential, and the likely permeability of the Tidal Flat Deposits underlying the site was recommended.

It was also strongly recommended that an asbestos survey of the existing buildings be undertaken by a licensed and experienced contractor, and that appropriate mitigation / removal of ACMs is carried out prior to, or as part of the demolition programme. This recommendation is outside the scope of this report.

1.3 Objectives

The overall objective of the works undertaken was to carry out a ground investigation and an assessment of the site to inform the Client of any potential ground-related risks associated with the redevelopment of the site. This included the determination of the underlying ground and groundwater conditions, an assessment of the level of contamination at the site and the provision of initial geotechnical design recommendations based on the findings of the Phase 1 Desk Study as detailed in Section 1.2 of this report.

1.4 Scope of Works

The following scope of works was outlined by Grange GeoConsulting Limited in our fee proposal and scope of works issued to Mr James Kirk on behalf of the Client on the 7th February 2022. Authorisation to proceed with this report was given in February 2022.

- 1 day of dynamic (window) sampling to excavate 5 No. window sample boreholes (WS1 to WS5) at the site to enable the logging of the soils encountered and the collection of soil samples for geotechnical and chemical analysis. In-situ Standard Penetration Testing (SPTs) to be undertaken to assess the density of the underlying ground and

the installation of one groundwater and ground gas monitoring well (WS3) with one round of post-investigation monitoring as a precautionary measure;

- Undertaking of dynamic probing within two of the window sample boreholes (WS2 and WS4);
- 1 day of hand pitting to excavate 2 No. hand pits (HP1 and HP2) within stockpiled materials to enable the logging of the soils encountered and the collection of soil samples for chemical analysis;
- Chemical (contamination analysis) testing of soils;
- Geotechnical testing of soils; and
- Collaboration of the findings within a Phase 2 Ground Investigation Report.

1.5 Provided Information

The following drawings have been provided by Kirk Homes Limited to support the completion of this Phase 2 Report:

- South Holland District Council – Planning Decision (reference: H17-0005-21) to demolish existing farm buildings, remove concrete hardstanding and erection of new farm shop store, contractors' office, and storage yard; and
- P&R Architects Location Plans, Proposed Contractors Office / Store Plans and Elevations, Existing and Proposed Site Plans and Existing Barn Photographs.

1.6 Limitations

The spacing of the boreholes, and the sampling and analysis undertaken as part of the ground investigation, is considered to have provided a reasonable level of certainty about the ground conditions. However, it is important to recognise that contamination can be both widespread and relatively localised, depending upon its source and nature. No investigation, however comprehensive, can be expected to determine the nature and extent of all contamination that could be present, and there will always be an element of uncertainty. The potential for currently undetected contamination to be present must therefore be considered not only in the risk assessment presented within this report, but also in consideration of future development activities, i.e., health and safety planning and risk management.

This report has been prepared for the sole internal use and reliance of the Client, Kirk Homes Limited, and shall not be relied upon by other parties without the express written authority of Grange GeoConsulting Limited. If an unauthorised third party comes into possession of this report, they then rely on it at their own risk.

2.0 GROUND INVESTIGATION WORKS

2.1 Investigation Rationale

The ground investigation works rationale, summarised in Table 2.1, is based on the findings of the Phase 1 Desk Study for the site and the proposed development scheme.

Table 2.1: Investigation Rationale

Exploratory Holes	Purpose
Window Sample Boreholes (WS1 to WS5) Hand Pits (HP1 and HP2)	• Enable logging of the soils encountered and assess shallow ground and groundwater conditions; • Facilitate dynamic probing in WS2 and WS4; • Carry out in-situ Standard Penetration Testing (SPTs) to assess the density of the underlying ground; • Installation of one groundwater and ground gas monitoring well (WS3) with one round of precautionary monitoring; and • Allow the collection of soil samples for chemical (contamination analysis) and geotechnical testing. • Examine contamination associated with stockpiles located at the site (HP1 and HP2)

2.2 Site Works

The ground investigation was undertaken on the 9th March 2022. A selection of photographs taken during the works are presented in Appendix B.

The approximate positions of the window sample boreholes on site were surveyed using a tape measure, with distances measured from landmarks present nearby. The locations are shown in the Ground Investigation Plan (Drawing R21071-DWG2) which is presented in Appendix A.

The works undertaken are summarised in Table 2.2. The borehole and hand pit logs, including details of ground conditions, water strikes, any visual or olfactory evidence of contamination, the soil samples taken, and the in-situ testing are presented in Appendix C.

Table 2.2: Summary of Site Works

Exploratory Holes	Method	Depth (m)	In-situ testing	Observations
WS1	Window sample borehole	3m bgl	Standard Penetration Tests (SPTs) undertaken at 1m, 2m and 3m bgl. Low SPT values (2 to 4).	No visual or olfactory evidence of contamination. Groundwater at 1.25m bgl after 20 minutes.
WS2	Window sample borehole	3m bgl	SPTs undertaken at 1m, 2m and 3m bgl. Low SPT values (2 to 5).	No visual or olfactory evidence of contamination. Groundwater at 1.25m bgl after 20 minutes.

Exploratory Holes	Method	Depth (m)	In-situ testing	Observations
WS3	Window sample borehole	3m bgl	SPTs undertaken at 1m, 2m and 3m bgl. Low SPT values (2 to 4).	No visual or olfactory evidence of contamination. Groundwater at 1.3m bgl after 20 minutes. Monitoring well installed to 2.8m bgl (response zone between 1m and 2.8m bgl).
WS4	Window sample borehole	3m bgl	SPTs undertaken at 1m, 2m and 3m bgl. Low SPT values (2 to 4).	No visual or olfactory evidence of contamination. Groundwater at 1.3m bgl after 20 minutes.
WS5	Window sample borehole	3m bgl	SPTs undertaken at 1m, 2m and 3m bgl. Low SPT values (1 to 2).	No visual or olfactory evidence of contamination. Groundwater at 1.2m bgl after 20 minutes.
HP1	Hand Pit	0.5m bgl	None undertaken.	Rare ash noted in Made Ground. No groundwater recorded.
HP2	Hand Pit	0.5m bgl	None undertaken.	No visual or olfactory evidence of contamination. No groundwater recorded.

2.3 Ground Conditions

The British Geological Survey (BGS) indicates the site to be underlain by superficial Tidal Flat Deposits of Quaternary age. These are generally detrital sedimentary deposits of shallow marine origin resulting from the repeated covering and uncovering of marshy land within the intertidal zone and are typically described as soft silty clay with subordinate layers of sand, gravel, and peat.

The bedrock underlying the site is recorded to comprise mudstone from the Oxford Clay Formation, of Jurassic age. These materials are detrital and shallow marine in origin, forming interbedded coarse to fine grained strata. floodplains and levees of a river or estuary. Locally these deposits are typically described as grey silica rich mudstones with sporadic beds of limestone nodules.

The ground conditions across the site, as proven during the ground investigation are in accordance with the published geological literature. The ground conditions are presented in full in the borehole logs in Appendix C and summarised in Table 2.3.

Table 2.3: Strata Encountered

Stratum Description	Depth to Top (m bgl)	Depth to Base (m bgl)	Thickness (m)
Made Ground (WS5, HP1 and HP2 only) Brown, silty, slightly sandy clay and clayey or gravelly sand with concrete and quartzite. Rare ash noted in HP1.	Ground level	0.2m to 0.5m bgl	0.2m in WS5 Unproven at 0.5m bgl in HP1 and HP2

Stratum Description	Depth to Top (m bgl)	Depth to Base (m bgl)	Thickness (m)
Topsoil Dark brown, sandy silt.	Ground level	0.2m to 0.4m bgl	0.2m to 0.4m
Tidal Flat Deposits Loose to very loose, light brown, brown, yellow brown, orange and grey mottled, clayey, silty sand, and clayey sand.	0.2m to 0.4m bgl	Unproven at the deepest part of the investigation at 3m bgl	Unproven at the deepest part of the investigation at 3m bgl

2.3.1 Made Ground

Made Ground was encountered in HP1 and HP2, which were excavated within two stockpiles of unknown provenance identified during the Phase 1 Desk Study. Material encountered within the stockpiles was described as brown, silty, slightly sandy clay and clayey sand. Rare ash was noted in the stockpile at HP1.

Made Ground was encountered in WS5 at ground level, overlying the Tidal Flat Deposits. The stratum was 0.2m thick and was logged as a brown, gravelly sand. The gravels comprised fine to coarse concrete and sub-rounded quartzite.

2.3.2 Topsoil

Topsoil was encountered in WS1, WS2, WS3 and WS4 at ground level and was underlain by the Tidal Flat Deposits. The stratum was logged as a dark brown, sandy silt.

2.3.3 Tidal Flat Deposits

The Tidal Flat Deposits were logged as a light brown, brown, yellow brown, orange and grey mottled, clayey, silty sand, and clayey sand. The stratum was noted to become grey below 2m bgl.

The stratum was encountered on site underlying the Topsoil in WS1, WS2, WS3 and WS4 and by the Made Ground in WS5 and depths between 0.2m and 0.4m bgl. The thickness of the stratum was unproven at 3m bgl within the boreholes. The stratum was not encountered within the hand pits which were terminated at 0.5m bgl.

2.3.4 Borehole Stability

No evidence of borehole instability was recorded during the ground investigation.

2.4 Visual and Olfactory Evidence of Contamination

Rare ash was encountered in the upper 0.1m in HP1. This material, based on visual inspection appeared to be a result of localised burning/bonfire. No further visual or olfactory evidence of contamination was noted on site in soils or groundwater.

2.5 Groundwater

Groundwater was recorded in the window sample boreholes twenty minutes following the completion of the drilling on site. Groundwater depths within the Tidal Flat Deposits were 1.2m bgl (WS2 and WS5), 1.25m bgl (WS1) and 1.3m bgl (WS3 and WS4). No evidence of contamination was noted in the groundwater.

A monitoring well was installed to 2.8m bgl in WS3, with a response zone between 1m and 2.8m bgl. One round of post-investigation monitoring was carried out on 17th March 2022. During this monitoring visit, groundwater was recorded at a depth of 1.4m bgl.

2.6 Standard Penetration Testing (SPTs)

Standard Penetration Tests were undertaken within the window sample boreholes to a maximum depth of 3m bgl. Low values were recorded. The SPT results (N values) recorded are presented in Table 2.4.

Table 2.4: In-situ testing results (SPT values)

Exploratory Holes	SPT (N value) at m bgl		
	1m	2m	3m
WS1	4	2	4
WS2	5	2	2
WS3	4	2	2
WS4	2	2	3
WS5	2	2	1

3.0 LABORATORY TESTING SCOPE

3.1 Chemical (Contamination Analysis) Testing

3.1.1 Sampling Strategy

The locations selected to advance the window sample boreholes were spaced to provide general site coverage. The hand pits were targeted to investigate the stockpile and bonfire on site. The borehole spacing is considered to have provided a reasonable level of certainty about the ground conditions. The following samples were taken by Grange GeoConsulting Limited on the 9th March 2022:

- 3 No. samples from the Made Ground; and
- 4 No. samples from the Topsoil.

Samples were taken, stored, and transported in general accordance with the British Standard 10175: 2011 Code of Practice for Investigation of Potentially Contaminated sites, and transported by courier to I2 Analytical Services; a UKAS accredited laboratory.

3.1.2 Laboratory Analyses Undertaken

The samples collected were scheduled to be tested for the following contaminants (Grange GeoConsulting Limited default suite of determinands) for soils comprising:

Arsenic (As), Cadmium (Cd), Hexavalent and Total Chromium (Cr II and VI), Copper (Cu), Lead (Pb), Nickel (Ni), Selenium (Se), Zinc (Zn), Total Cyanide, pH, Organic Matter, Asbestos Screen and Speciated Total Poly-Aromatic Hydrocarbons (PAHs).

Limited testing was also carried out for Speciated Total Petroleum Hydrocarbons (TPH-CWG aromatic and aromatic fractions), Methyl Tertiary Butyl Ether (MTBE) and BTEX (Benzene, Toluene, Ethylbenzene and Xylenes), Volatile and Semi-Volatile Organic Compounds (VOCs and SVOCs), Pesticides, Dioxins and Furans.

3.2 Geotechnical Testing

3.2.1 Sampling Strategy

Six samples were taken by Grange GeoConsulting Limited on the 9th March 2022 for geotechnical testing. The samples were taken from the Tidal Flat Deposits. Samples were taken, stored, and transported in general accordance with good practice as detailed above in Section 3.1.1.

3.2.2 Laboratory Analyses Undertaken

Laboratory analysis was undertaken to assess the density of the underlying ground, and to inform the design of the foundations. The following analyses were undertaken:

- 10 No. natural moisture content tests and pH testing undertaken as part of the chemical testing for contamination and geotechnical purposes; and
- 5 No. Particle Size Distribution (PSD) tests;
- 1 No. remoulded CBR test; and
- 3 No. Total Sulphate, Water Soluble Sulphate, Water Soluble Chloride, Water Soluble Nitrate, Magnesium and Total Sulphate tests.

4.0 CONTAMINATION RISK ASSESSMENT CRITERIA

A risk-based approach is used for the assessment of contamination. This requires identification of a contaminant source, a receptor, and a realistic pathway via which the contaminant may reach the receptor. The key receptors considered in this assessment are human health (staff, visitors, groundworkers and maintenance workers, neighbours, and members of the public) and to a lesser extent, controlled waters (groundwater, though likely to be limited due to the designation by the Environment Agency of Unproductive Strata underlying the site).

The Risk Assessment is a two-stage process. The first stage is to perform a Generic Quantitative Risk Assessment (GQRA), where the soil test results have been compared against the relevant Generic Assessment Criteria (GAC). In the absence of a complete regulatory set of screening values, derived using the CLEA Framework, Grange GeoConsulting Limited GAC screening values have been utilised and are based on the following:

- Category 4 Screening Levels (C4SLs) published by DEFRA;
- The 2014 Land Quality Management (LQM) / Chartered Institute of Environmental Health (CIEH) Suitable for Use Levels for Human Health Risk Assessment (S4ULs); and
- Guidance values produced by the Environmental Industries Commission (EIC), the Association of Geotechnical and Geoenvironmental Specialists (AGS), and Contaminated Land: Application in Real Environments (CL:AIRE) in December 2009.

The second stage of the Risk Assessment process is Risk Evaluation, which comprises an authoritative review of the findings with other pertinent information in cases where the GAC are exceeded, to consider if exceedance may be acceptable in the context of the site.

4.1 Human Health Risk Assessment

This is a Tier 2 assessment, using GAC soil screening values, and involves generic human health risk assessment for the CLEA scenario: **Public Open Space (Resi).** It should be noted that this is a very conservative risk assessment, given the nature and use of the site for commercial purposes as a contractor's yard / office, and a storage unit for the nearby Farm Shop.

The chemical (contamination analysis) testing results have been screened against Grange GeoConsulting Limited GAC screening values (provided in Appendix D) to carry out an assessment of potential risks associated with contamination at the site. Justification for the criteria adopted for this Risk Assessment is given in D. In the case where all the samples tested for a given substance were below the GACs, no further consideration is necessary for that substance.

The excavations carried out during the current site investigation were in part positioned in order to target potential contamination sources identified during the Phase 1 Desk Study. As a result, data obtained from laboratory chemical testing is considered unsuitable for statistical analysis. Contaminant concentrations recorded during chemical analysis have therefore been directly compared with GACs.

GAC based on a Soil Organic Matter Content (SOM) of 1% have been used. This is a conservative approach given that the average SOM for the Made Ground and natural strata on site is 2.3%. The lowest SOM recorded was 1.3% and the highest value was 3.5%.

The pH of the contamination and geotechnical samples taken on site ranged between 8.1 and 8.7. The average pH value was 8.42 indicating an alkaline pH value on site.

5.0 CONTAMINATION ANALYSIS TESTING RESULTS AND RISK ASSESSMENT

5.1 Soil Analysis Results

5.1.1 Inorganic Contaminants (including Metals and Metalloids)

None of the metal/semi-metal or inorganic contaminants tested were considered to be significantly elevated, or recorded at concentrations which exceeded GACs for a public open space (resi) end-use scenario in any of the samples tested.

5.1.2 Total Petroleum Hydrocarbons (TPHs)

None of the individual carbon bands analysed during the Ground Investigation exceeded the adopted Generic Assessment Criteria in any of the analysed samples.

5.1.3 Polycyclic Aromatic Hydrocarbons (PAHs)

Whilst slightly elevated concentrations of individual PAH species were recorded in the sample taken from the stockpile at HP1, none of the samples tested during the investigation proved concentrations exceeding relevant GACs for a Public Open Space (Resi) end use scenario, taking into consideration the appropriate SOM content.

5.1.4 Asbestos

The concentration of asbestos within each of the samples analysed during the site investigation was found to be below qualitative (microscopy) laboratory levels of detection (<0.001%).

5.1.5 BTEX and MTBE

None of the individual compounds collectively referred to as BTEX, or MTBE were recorded at concentrations of in excess of laboratory levels of detection within the sample tested.

5.1.6 Pesticides

A sample taken from WS1 at a depth of 0.1m bgl proved trace concentrations of several pesticide compounds; DDD-p-p, DDE-p-p, DDT-p-p, and Pendimethalin. The concentrations of these determinands were 33µg/km, 44µg/kg, 24µg/kg and 15µg/kg respectively.

No UK soil guideline values have been derived for DDD, DDE or DDT, however for the purpose of context, the US EPA have published Regional Screening Levels for the identified contaminants in soils. These screening levels are 1900µg/kg (DDD), 2000µg/kg (DDE), and 1900µg/kg (DDT). The samples tested were several orders of magnitude below these criteria.

Whilst these compounds are persistent in the environment (exhibiting half lives of between 2 and 15 years), it should be noted that DDE and DDD are metabolites of DDT. The presence of these compounds in the sample taken from WS1 would therefore suggest that the contamination is of significant age, and that degradation is occurring.

No screening criteria have been developed with respect to Pendimethalin, however a material safety data sheet obtained for this contaminant (included in Appendix E) indicates relatively low toxicity (Oral LD50 1,050mg/kg). A study undertaken on environmental fate undertaken by the US EPA for Pendamethalin (findings included in Appendix E) indicate that this determinand exhibits a relatively short half life in aerobic soil conditions of between 21 and 172 days.

Based on the above information, the trace concentrations of pesticides identified during the investigation are not considered to represent a significant risk to the proposed development.

5.1.7 Dioxins and Furans

The sample obtained from the stockpile at HP1, where visual evidence of a fire was noted during the investigation, proved concentrations of a number of Furan and Dioxin congeners.

A full list of the compounds identified is presented in Appendix F . A summary of the findings is presented below.

The total concentration of Furans identified in the sample taken from HP1 was 62.6ng/kg (0.0626µg/kg). The toxic equivalence factor (TEQ) for the identified contaminants was 2.71, resulting in a screening concentration of 169.7ng/kg (0.170µg/kg).

Total dioxin concentration recorded was 98.5ng/kg (0.099µg/kg), with a worst case TEQ (bird life) of 4.86, resulting in a screening factor of 478.7ng/kg (0.479µg/kg).

Whilst no current guideline values have been published with respect to these contaminants, a science report (SC050021) previously published by the Environment Agency established a series of Soil Guideline Values for dioxins and furans. No exposure scenario equivalent to POS(Resi) was established in the report. The closest analogous land use scenario modelled for the study was for commercial use. The commercial SGV for the sum of dioxins and furans was given as 240µg/kg.

The recorded contaminant concentrations were well below this criterion, and as a result are not considered to represent a significant risk to the proposed development.

5.2 Ground Gas

A single ground gas monitoring visit was undertaken at the site on 17th March 2022 in order to characterise conditions within the standpipe installed during the investigation (WS3).

The gas monitoring certificate is included in Appendix G, and the results are summarised in Table 5.1.

Table 5.1. Ground Gas Monitoring Results 17th March 2022

Exploratory Hole	Max CH_4 Conc. (%vol)	Max CO_2 Conc. (%vol)	Min O_2 Conc. (% vol)	Max Flow Rate (l/hr)	Atmospheric Pressure (mb)
WS3	0.0	0.9	19.1	1.0	1019

Methane was not recorded above limits of detection within any of the boreholes during the monitoring visit. The highest carbon dioxide concentration recorded was 0.9%. The minimum oxygen concentration recorded was 19.1%. The highest recorded gas flow rate was 1.0l/hr.

Based on the guidance in BS 8485:2015+A1:2019, a preliminary calculation of the hazardous gas flow rate (Q_{hg}) has been undertaken based on the maximum concentration of a hazardous gas observed on site, which in this instance was carbon dioxide, as methane concentrations were below levels of detection. For the purpose of this calculation, the flow rate was taken as 1.0l/hr. The preliminary Q_{hg} estimate is provided below:

Q_{hg} = 1.0 x (0.9/100) = 0.009 l/hr

The findings of the site investigation would suggest a worst case Q_{hg} of 0.009 l/hr for the site, which would indicate that Characteristic Situation 1-'Very Low Risk' (CS1) would be an appropriate classification with regard to new developments.

Details provided by the client about the proposed development suggest that the buildings would be of 'Type C' (as per Table 3 of the BS8485). On this basis (CS1 designation, and building Type C) the gas protection score for the site would therefore be '0' in accordance with Table 4 of the guidance document.

According to BS8485:2015, this designation would not require specific mitigation measures.

It is acknowledged that the monitoring programme, designed to characterise any ground gas issues, may not be sufficient to fully classify the site in accordance with the methodology established in current guidance. Should such a classification be required, further monitoring visits are likely to be required.

5.3 Radon

As discussed within the previous Phase 1 Desk Study, the Indicative Atlas of Radon for England and Wales indicates the site to be within a lower probability radon area (where less than 1% of the homes are estimated to be at or above the Action Level). Consequently, the BGS and the Building Research Establishment Radon Guidance Document indicate that no radon protection measures for buildings are required in this area.

6.0 REVISED RISK ASSESSMENT

6.1 Revised Ground Model

The preliminary conceptual site model initially developed from the Grange GeoConsulting Phase 1 Desk Study (Report reference R21036/001) has been updated using the findings of the ground investigation.

6.2 Revised Exposure Model

The plausible contaminant sources, pathways, and receptors previously identified in the Phase 1 Desk Study, and summarised in Section 1.2 have been updated based on the findings of the Phase 2 Ground Investigation

6.2.1 Sources

The laboratory chemical analysis results have identified the presence of nominal/trace contamination at the site.

Laboratory analysis results of samples taken from the Stockpile at HP1 proved concentrations of a number of Furan and Dioxin congeners. The concentrations recorded, however, were not considered to represent a significant risk to the proposed development.

A sample taken from WS1 at a depth of 0.1m bgl proved trace concentrations of several pesticide compounds; DDD-p-p, DDE-p-p, DDT-p-p, and Pendimethalin. The trace concentrations of pesticides identified during the investigation were not considered to represent a significant risk to the proposed development.

No additional contamination attributable to the on and off-site potential contamination sources identified during the Phase 1 Desk Study was identified during the Site Investigation.

6.2.2 Receptors

The potential receptors identified during the Phase 1 Desk Study included the following:

- Site end users (future occupational site users, visitors, and neighbours)
- Groundworkers (construction, demolition, and future maintenance workers)
- Building materials (buried concrete and underground services)
- Controlled waters: Surface waters- Drainage channel located 4m east of the site, and hydraulically linked River Glen (overland flow and surface run-off)

Based on the findings of the Ground Investigation, no potential receptors have been removed from the preliminary conceptual exposure model.

6.2.3 Pathways

The potential pathways identified during the Phase 1 Desk Study for the site included:

- Direct human contact (construction/demolition phase)
- Inhalation (dust and vapours)
- Ingestion (direct, and dust- the cultivation of homegrown produce is considered unlikely following redevelopment)
- Direct contact with aggressive ground conditions
- Leaching and migration of contamination via groundwater and surface water runoff.
- Migration of ground gas and vapours

Since no changes have been made to the proposed development, the previously identified potential pathways are therefore considered to remain plausible.

6.3 Revised Conceptual Site Model and Risk Assessment

A revised Conceptual Site Model (Table 6.2) has been produced which presents an updated list of plausible contaminant linkages based on information obtained during the site investigation, and an evaluation of these linkages in accordance with the guidance provided in Environment Agency (2020) Land Contamination Risk Management. (LCRM). The evaluation of potential linkages has been undertaken in general accordance with guidance provided in the CIRIA Report C552 (Rudland *et al* 2001) but with the addition of a 'no linkage' category as detailed below in Table 6.1.

The contaminant sources/hazards described in Section 6.2 have been assessed according to the severity of potential consequences when reaching a receptor, as described in CIRIA C552 report (2001). This is known as environmental harm and can be classified as minor, mild, medium, or severe.

The likelihood/probability that a potential pollutant linkage may become established has been assessed on the basis of the revised ground and exposure models (Sections 6.1 and 6.2), and with reference to potential future development options. The likelihood ascribed to each identified potential linkage is provided in the final CSM (Table 6.2).

An overall classification of risk is obtained by combining the potential severity of the contaminant source or consequence of a linkage becoming established, and the probability that a given pollutant linkage may become established. Table 6.1 shows possible overall risk classifications based on various combinations of source severity and probability of receptor impact. The overall risk associated with each of the identified potential pollutant linkages is provided in the CSM (Table 6.2). The resulting implications, and recommendations are presented in Section 7.0.

Table 6.1: Risk Assessment Categories

		Consequence			
Probability		**Severe**	**Medium**	**Mild**	**Minor**
	High Likelihood	Very high risk	High risk	Moderate risk	Low risk
	Likely	High risk	Moderate risk	Low risk	Very low risk
	Low Likelihood	Moderate risk	Low risk	Low risk	Very low risk
	Unlikely	Low risk	Very low risk	Very low risk	Very low risk
	No Linkage	No risk			

It should be noted that whilst the risk assessment process undertaken in this report may identify potential risks to groundworkers (construction and future maintenance workers), consideration of occupational health and safety issues is beyond the scope of this report and needs to be considered separately in the Construction Phase Health and Safety Plan.

Table 6.2: Conceptual Site Model - Source Pathway Receptor Contaminant Linkages

Source(s)	Possible Pathway(s)	Receptor(s)	Probability	Consequence	Risk	Comments
On-Site: Potentially Organic Tidal Flat Deposits COC: Ground Gases	Migration of ground gases via permeable soils	Site end users, Groundworkers, Building Materials,	Unlikely	Medium	Very Low	The Tidal Flat deposits underlying the site were considered during the Phase 1 Desk Study to potentially possess gas generation potential. Subsequent investigation works have proven ground gas concentrations to be low, equivalent to a CS1 classification. The proposed development will comprise commercial use, resulting in occupational exposure scenarios. The end use will include offices with small to moderate room sizes. It is considered possible that workers will come into contact with ground gases during the demolition and construction phases. The proposed presence of permeable external areas (gravel and permeable paving) will enable vertical migration of ground gases. The Tidal Flat and Oxford Clay Formation deposits anticipated to underlie the site have been designated Unproductive units by the Environment Agency. These strata are also likely to exhibit very low permeability, which will limit the mobility of ground gases.

Source(s)	Possible Pathway(s)	Receptor(s)	Probability	Consequence	Risk	Comments
On-Site: Soil/rubble stockpiles COC: Metals, Semi-metals, TPHs, PAHs, asbestos, pH adjusters, furans, dioxins	Direct human contact (demolition phase) Inhalation Ingestion Leaching and migration via groundwater and surface water	Groundworkers, Building Materials, Controlled waters: Surface water	Likely	Mild	Low Risk	Stockpiles of refuse, rubble and soil were noted at the site during the site walkover. One of these stockpiles exhibited visual evidence of recent combustion. The stockpiles have been sampled, and subjected to a range of testing. Trace concentrations of dioxins and furans were identified in the stockpile at HP1, however these concentrations are not considered to represent a significant risk to the proposed development, or to controlled water receptors. It is assumed that these stockpiles will be dealt with during the demolition phase of the development. Based on the analysis results obtained, reuse of the stockpiled material on site may be possible, subject to waste management regulations. It is considered likely that workers will come into direct contact with trace contaminants during the demolition phase. The proposed presence of permeable external areas (gravel and permeable paving) will enable infiltration of meteoric water, and vertical migration of contaminants. The Tidal Flat and Oxford Clay Formation deposits anticipated to underlie the site have been designated Unproductive units by the Environment Agency, and are not considered a significant controlled water receptor. These strata are also likely to exhibit very low permeability, which will favour lateral rather than vertical migration of contaminants. The closest surface water receptor is located 4m east of the site.

Source(s)	Possible Pathway(s)	Receptor(s)	Probability	Consequence	Risk	Comments
On and Off-site: Agricultural Use COC: Pesticides/ herbicides	Leaching and lateral migration onto site via groundwater and surface water, Direct human contact (demolition and construction phases) Inhalation Ingestion	Site end users, Groundworkers, Building Materials, Controlled waters: Surface water	Likely (construction/ demolition workers, controlled waters) Low Likelihood (Site End Users)	Mild	Low	The site and surrounding areas have been subject to agricultural use throughout recent recorded history. Continued agricultural use of the surrounding areas was observed during the site walkover. Samples taken during the site investigation proved slightly elevated concentrations of pesticides (DDT, DDD, DDE, and Pendimethalin) in one location (WS1 at 0.1m bgl). Based on subsequent evaluation of the results, the recorded concentrations are not considered to represent a significant risk to human health or controlled water receptors. In addition, the severity of impact to groundworkers and site end users is limited by occupational exposure, and limited potential for ingestion. The proposed development will comprise commercial use, resulting in occupational exposure scenarios. These scenarios include limited dermal pathways, and attenuated inhalation and ingestion pathways. No landscaping is proposed as part of the development. It is considered likely that workers will come into direct contact with contaminants during the demolition and construction phases. The proposed presence of permeable external areas (gravel and permeable paving) will enable infiltration of meteoric water, and vertical migration of contaminants. The Tidal Flat and Oxford Clay Formation deposits anticipated to underlie the site have been designated Unproductive units by the Environment Agency, and are not considered a significant controlled water receptor. These strata are also likely to exhibit very low permeability, which will favour lateral rather than vertical migration of contaminants. The closest surface water receptor is located 4m east of the site.

6.4 Residual Risks

The Conceptual Site Model has enabled the examination of possible sources, pathways and receptors which were identified during the intrusive ground investigation, and the evaluation of plausible contaminant linkages considered to represent a potential risk following redevelopment of the site.

Based on the magnitude of harm and the likelihood of a pollutant pathway being established, and the findings of the intrusive investigation it is considered that following redevelopment (in accordance with current proposals), a **Low** risk of harm to human health receptors will remain as a result of contamination present within soils at the site.

The risk to controlled waters resulting from contamination at the site following redevelopment is considered **Low**.

7.0 FURTHER RECOMMENDATIONS

No significant contamination was identified during the investigation. The Revised Risk Assessment undertaken during the current investigation works concluded that following redevelopment risk to human health and controlled water receptors will be low. Whilst no specific remedial/mitigation works are considered necessary at this stage, several recommendations have been made, which if implemented would further reduce associated risk:

- It is recommended that construction/earthworkers use appropriate PPE and RPE, and that an appropriate safe working plan is established by the relevant contractors prior to commencement of works. The objective of these measures would be to mitigate the potential for direct contact, ingestion, and inhalation pathways to become established with respect to site workers.
- A watching brief should be maintained for contamination throughout the duration of the proposed development. In the event that any unforeseen gross or widespread contamination is encountered on site (i.e., hydrocarbons, asbestos etc). Grange GeoConsulting Limited (or another appropriately qualified contaminated land specialist) should be contacted immediately. A representative will be able to attend site, examine any potentially contaminated materials, take soil samples as required, and provide specialist advice. This would be recorded and communicated to the Local Planning Authority (LPA) and an appropriate course of action determined;
- Any unexpected contamination encountered during the development should be subject to appropriate management (i.e., stopping of works, adoption of quarantine measures, minimisation of further impacts to the environment and human health as appropriate);
- Specialist contractors should be employed as necessary to advise on the management of unexpected contamination.

8.0 GEOTECHNICAL LABORATORY TESTING RESULTS

The results of the geotechnical testing programme are summarised in the following section of the report, enabling preliminary geotechnical/foundation design for the proposed development.

8.1 Natural Moisture Content

Eleven natural moisture content tests were undertaken on the samples collected as part of the contamination and geotechnical testing. The samples recorded natural moisture content values between 9.5% and 27%. The average natural moisture content value recorded was 15.82%.

8.2 pH Value

The pH for the contamination and geotechnical samples taken on site ranged between 8.1 and 8.7. The average pH value was 8.42 indicating an alkaline pH value on site.

8.3 Particle Size Distribution

Five Particle Size Distribution (PSD) tests on the Tidal Flat Deposits natural strata were undertaken. The results are presented in Table 8.1 and included in Appendix H.

Table 8.1: Particle Size Distribution Test Results

Stratum	Sample Depth	Sample Proportion (dry mass %)	Grading Analysis
Tidal Flat Deposits	WS1 (0.5m bgl)	71% Sand 22% Silt 7% Clay	D100mm: 2 D60mm: 0.0928 D30mm: 0.0641 D10mm: 0.00416 Uniformity Coefficient: 22 Curvature Coefficient: 11
	WS1 (1.5m bgl)	74% Sand 18% Silt 8% Clay	D100mm: 2 D60mm: 0.094 D30mm: 0.0657 D10mm: 0.00661 Uniformity Coefficient: 14 Curvature Coefficient: 6.9
	WS2 (0.8m bgl)	58% Sand 39% Silt 3% Clay	D100mm: 3.35 D60mm: 0.0829 D30mm: 0.0385 D10mm: 0.00631 Uniformity Coefficient: 13 Curvature Coefficient: 2.8
	WS2 (1.2m bgl)	70% Sand 30% Fines (<0.063mm)	D100mm: 3.35 D60mm: 0.0918 D30mm: 0.0632 Uniformity Coefficient: >1.5
	WS4 (0.6m bgl)	69% Gravel 31% Fines (<0.063mm)	D100mm: 5 D60mm: 0.0913 Uniformity Coefficient: >1.4

8.4 California Bearing Ratio (CBR)

One California Bearing Ratio (CBR) test within the Tidal Flat Deposits was undertaken. The results are presented in Table 8.2 and included in Appendix H.

Table 8.2: CBR Testing Results

Stratum	Sample Depth (m bgl)	Bulk Density (mg/m3)	Dry Density (mg/m3)	Specimen Preparation
Tidal Flat Deposits	0.5m to 1m bgl (WS5)	1.85mg/m3	1.45 mg/m3	Remoulded – recompacted with specified standard effort using 2.5kg rammer. Sample not soaked
Curve Correction Applied	**CBR Values (%)**			
	2.5mm	**5mm**	**Highest**	**Average**
Top: No	Top: 0.1%	Top: 0.3%	Top: 0.3%	-
Base: No	Base: 0.2%	Base: 0.4%	Base: 0.4%	

8.5 Sulphate Content

In accordance with BRE (Special Digest 1), the Design Sulphate (DS) classification and the Aggressive Chemical Environment for Concrete (ACEC) classification are presented in Table 8.3 and included in Appendix H.

Table 8.3: Aggressive Chemical Environment Concrete Classification

Stratum	No. of Tests	DS	ACEC
Tidal Flat Deposits	3	DS-1	AC-1

9.0 GEOTECHNICAL INTERPRETATION AND RECOMMENDATIONS

9.1 Foundations

Development proposals include the demolition of all existing structures, the removal of existing concrete hardstanding and the construction of two new 1-2-storey structures across the northern and southern sections of the site which will form a contractor's yard / office, and a storage unit for the nearby Farm Shop. In addition, vehicle parking areas and access roads will be constructed using permeable paving, and exterior yard areas (underlain by gravel) will be constructed across the western and south-western sections. At the time of the investigation proposed building loads had not been provided.

The allowable bearing pressure / design bearing pressure for foundations takes into consideration an acceptable load to take into account the risk of shear failure of the ground (ultimate limit state) and also acceptable limits of settlement (serviceability limit state).

The exploratory holes (excluding excavations undertaken on stockpiles) encountered Made Ground or Topsoil to a depth of between 0.2m and 0.4m bgl, overlying Tidal Flat Deposits.

The Tidal Flat Deposits, which were proven to depths in excess of 3m bgl were described as light brown, brown, yellow brown, orange and grey mottled, clayey, silty SAND, and clayey SAND.

Made Ground will not be suitable as a foundation stratum due to its inherent variability and risk of intolerable differential settlement. The natural Tidal Flat Deposits exhibited consistently low SPT values.

The Tidal Flat Deposits could be suitable as a founding stratum for the proposed development using strip or trench fill foundations, depending on required loadings. Care should be taken when selecting foundation depths in order to ensure that adjacent foundations are placed in materials of similar bearing and consolidation characteristics, thus avoiding any potential differential settlement. In addition, where extensions are proposed, foundation design should be sympathetic with the construction characteristics of the existing structure.

9.1.1 Shallow and Trenchfill Foundations

We would recommend that where strip and trench fill foundations are required within the low density predominantly granular materials of the Tidal Flat Deposits an allowable bearing capacity of 60kPa may be possible at depths of 0.5m bgl.

Foundations which span founding materials of different stiffness should have mesh reinforcement placed top and bottom of the foundation.

The depth of foundations should be designed, and the formations inspected by a geotechnical engineer. Any sub-formation materials deemed as unsuitable such as soft or loose zones should be excavated and replaced with well compacted suitable granular fill or lean mix concrete.

Foundation excavations should be protected from water and inclement weather including frost and any water should be removed by pumping from a sump in the base of the excavation.

Should the anticipated structural loadings exceed the allowable bearing pressures given above, alternative foundation options such as ground improvement and piles should be considered. Additional Site Investigation may be required to prove competent ground should a piled solution be adopted.

9.2 Ground Floor Slabs

Floor slabs should be constructed as suspended where Made Ground is greater than 600mm thickness, or foundations are located within the zone of influence of a (new planted) tree.

Ground floor slabs may be constructed as ground bearing providing foundations are not within the zone of influence of a tree, or where the floor slabs overlie natural materials. Where the Made Ground is predominantly granular in nature and less than 1.2m thick, ground bearing slabs may be suitable provided the Made Ground is compacted with a heavy vibrating roller and any soft spots removed and replace by granular fill.

9.3 External Pavement Design

Based on the near surface ground conditions encountered, and the findings of laboratory California Bearing Ratio (remoulded) testing undertaken, it is recommended for preliminary design purposes a CBR value of 0.2% is adopted where formation level is within the natural Tidal Flat deposits.

All formation excavations should be examined by a suitably experienced engineer or inspector to check for soft or unsuitable material, which should be removed and replaced with compacted granular fill. Also, to ensure good compaction and remove unevenness, the formation should be compacted with equipment suitable for use in the ground conditions encountered. Careful inspection of this work will also help identify any soft spots at or just below formation level.

9.4 Groundwater

Based on the findings of the investigation, groundwater may be encountered within shallow excavations, at depths of between 1.2m and 1.4m bgl.

9.5 Buried Concrete

Based on guidelines provided in BRE Special Digest 1, the Tidal Flat Deposits underlying the site may be classified as Design Sulfate Class DS-1 and ACEC Class AC-1.

This equates to a Designated Concrete Class DC-1 for a 50year design life (see BS 8500-1 for details).

10.0 REFERENCES

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APPENDICES

Appendix A DRAWINGS

Appendix B GROUND INVESTIGATION PHOTOGRAPHS

Appendix C WINDOW SAMPLE BOREHOLE AND HAND PIT LOGS

Appendix D GRANGE GEOCONSULTING LIMITED METHODOLOGY

Appendix E CONTAMINANT DATA (PENDAMETHALIN)

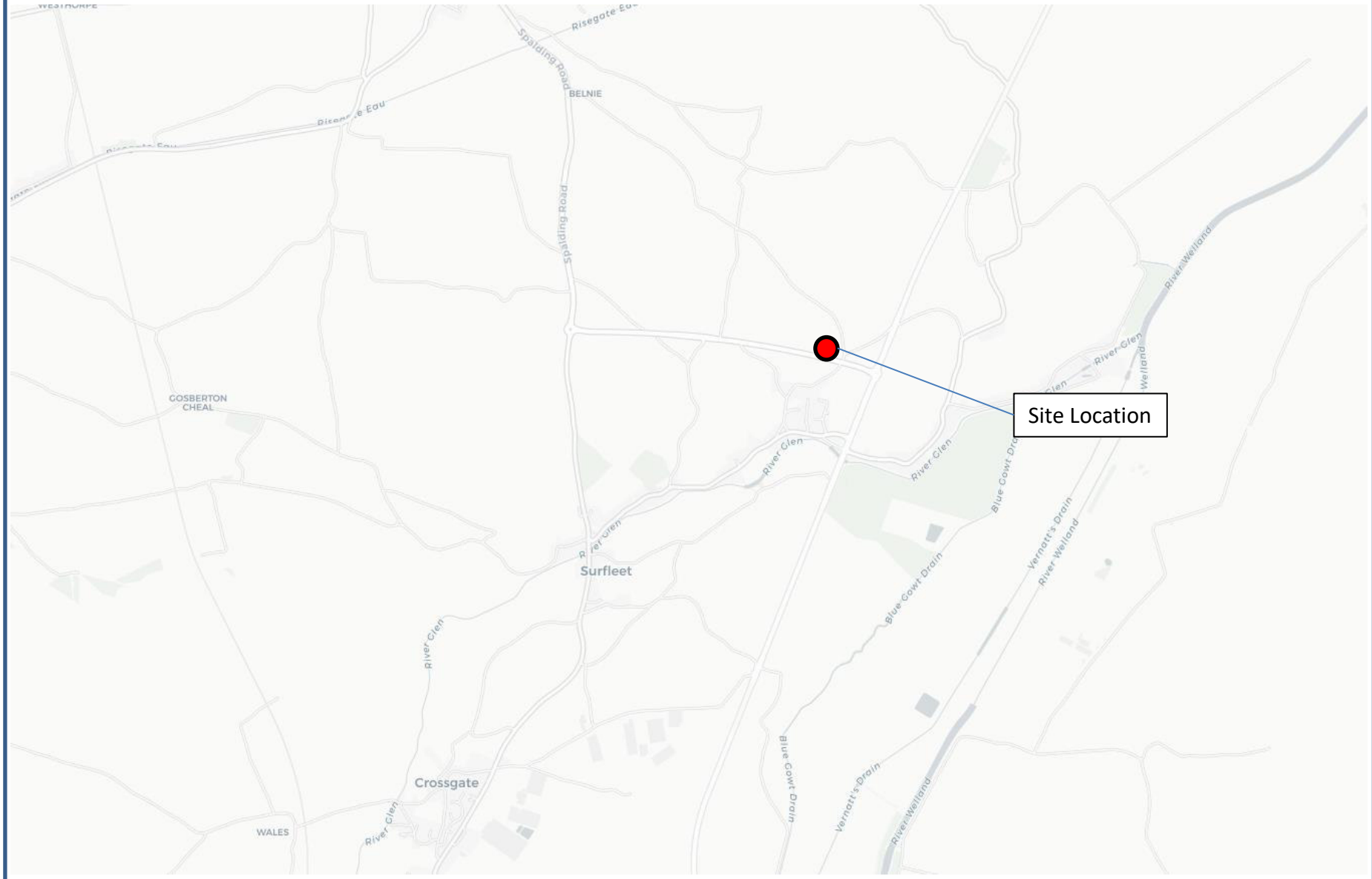
Appendix F CONTAMINATION TESTING RESULTS

Appendix G GROUNDWATER AND GROUND GAS MONITORING RESULTS

Appendix H GEOTECHNICAL TESTING RESULTS

Appendix A

DRAWINGS



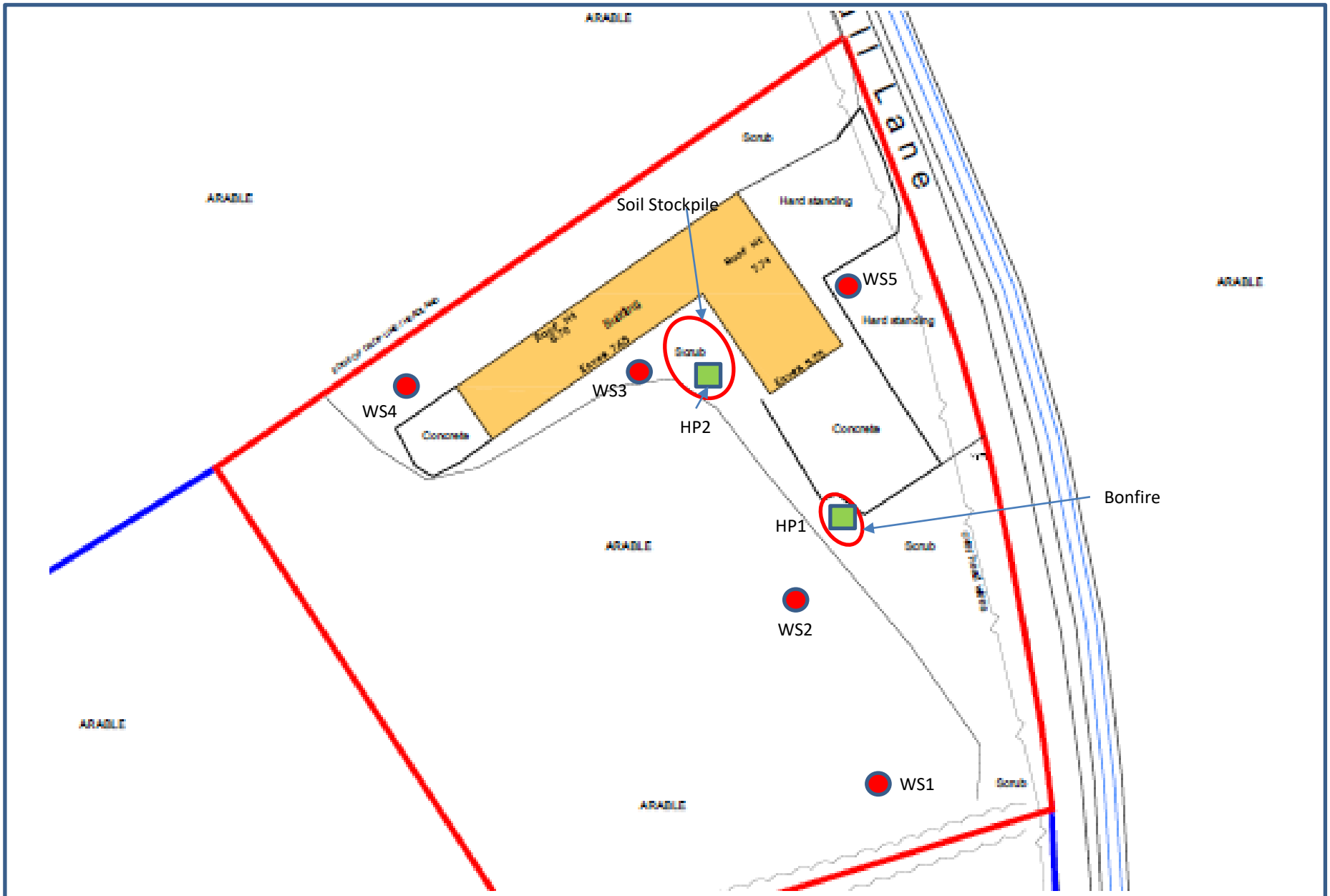
Grange Geo

Site Location Plan
Scoldhall Lane, Surfleet

Client- Kirk Homes Ltd.
Date- May 2022

North

R21071-DWG1



Grange Geo

Exploratory Hole Location Plan

Smithfield, Scoldhall Lane, Surfleet

Client: Kirk Homes

Date: May 2022

North

R21071-DWG2

Appendix B

GROUND INVESTIGATION PHOTOGRAPHS









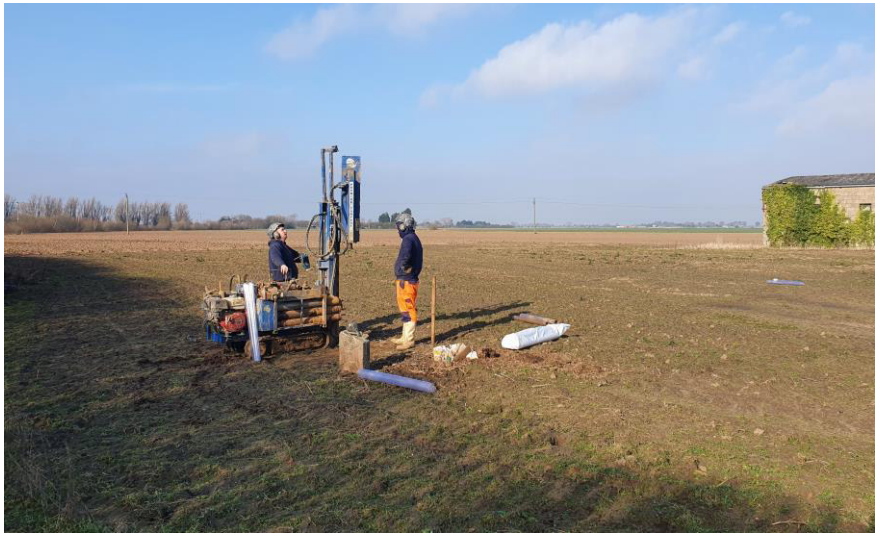
Grange Geo

Photo Record

Smithfield, Scoldhall Lane, Surfleet

Client: Kirk Homes Ltd

Appendix B







Grange Geo	**Photo Record** Smithfield, Scoldhall Lane, Surfleet	**Client**: Kirk Homes Ltd	**Appendix B**







Appendix C

WINDOW SAMPLE BOREHOLE AND HAND PIT LOGS

Window Sample Log

WS No: **1**

Client: Kirk Homes Ltd
Project: Smithfield, Scoldhall Lane, Surfleet

Sheet: 1 of 1
Method: Dynamic Window Sample

Sample Depth (m)	Sample Type	Testing result	Description	Depth mBGL	Legend
			Topsoil, dark brown, sandy SILT.		
0.5			Loose to very loose, light brown, clayey, silty, SAND. (Tidal Flat Deposits)		
1	SPT	N = 4		1	
1.5					
2	SPT	N = 2	becoming grey.	2	
2.5					
3	SPT	N = 4		3	
			End of borehole.	4	
				5	

General Comments:

1. Groundwater at 1.25m after 20 minutes.
2. No visual or olfactory evidence of contamination.
3.

Scale:
Date: 09/03/2022
Logged by: AH
Checked: SW
Job No: R21071

Grange Geo Consulting Ltd

Window Sample Log

WS No: 2

Client: Kirk Homes Ltd
Project: Smithfield, Scoldhall Lane, Surfleet

Sheet: 1 of 1
Method: Dynamic Window Sample

Sample Depth (m)	Sample Type	Testing result	Description	Depth mBGL	Legend
			Topsoil, dark brown, sandy SILT.		
0.5			Loose, yellow brown and grey mottled, slightly clayey, very silty SAND. (Tidal Flat Deposits)		
1	SPT	N = 5		1	
			Loose to very loose, brown, clayey SAND.		
2	SPT	N = 2		2	
2.5			Becoming grey in colour.		
3	SPT	N = 2		3	
			End of borehole.		

General Comments:

1. Groundwater at 1.20m after 20 minutes.
2. No visual or olfactory evidence of contamination.
3.

Scale:
Date: 09/03/2022
Logged by: AH
Checked: SW
Job No: R21071

Grange Geo Consulting Ltd

Window Sample Log

WS No: **3**

Client: Kirk Homes Ltd
Project: Smithfield, Scoldhall Lane, Surfleet

Sheet: 1 of 1
Method: Dynamic Window Sample

Sample Depth (m)	Sample Type	Testing result	Description	Depth mBGL	Legend
			Topsoil, dark brown, sandy SILT.		
0.5			Loose to very loose, yellow brown and grey mottled, slightly clayey, very silty SAND. (Tidal Flat Deposits)		
1	SPT	N = 4		1	
1.5					
2	SPT	N = 2	Becoming grey.	2	
2.5					
3	SPT	N = 2		3	
			End of borehole.		

General Comments:

1. Groundwater at 1.3m after 20 minutes.
2. Ground gas and groundwater monitoring well installed to 2.8m bgl. Response zone from 1m to 2.8m bgl.
3. No visual or olfactory evidence of contamination.

Scale:
Date: 09/03/2022
Logged by: AH
Checked: SW
Job No: R21071

Grange Geo Consulting Ltd

Window Sample Log

WS No: 4

Client: Kirk Homes Ltd
Project: Smithfield, Scoldhall Lane, Surfleet

Sheet: 1 of 1
Method: Dynamic Window Sample

Sample Depth (m)	Sample Type	Testing result	Description	Depth mBGL	Legend
			Topsoil, dark brown, sandy SILT.		
0.5			Yellow brown and grey mottled, clayey, SAND. (Tidal Flat Deposits)		
1	SPT	N = 2		1	
1.5					
2	SPT	N = 2		2	
2.5					
3	SPT	N = 3		3	
			End of borehole.		

General Comments:

1. Groundwater at 1.3m after 20 minutes.
2. No visual or olfactory evidence of contamination.
3.

Scale:
Date: 09/03/2022
Logged by: AH
Checked: SW
Job No: R21071

Grange Geo Consulting Ltd

Window Sample Log

WS No: 5

Client: Kirk Homes Ltd
Project: Smithfield, Scoldhall Lane, Surfleet

Sheet: 1 of 1
Method: Dynamic Window Sample

Sample Depth (m)	Sample Type	Testing result	Description	Depth mBGL	Legend
			Made Ground, brown, gravelly, SAND. Gravels of fine to coarse concrete and sub-rounded quartzite.		
			Orange brown, silty, SAND. (Tidal Flat Deposits)		
0.5					
			Very loose, brown, clayey SAND. (Tidal Flat Deposits)		
1	SPT	N = 2		1	
1.5					
2	SPT	N = 2	Becoming grey.	2	
2.5					
3	SPT	N = 1		3	
			End of borehole.		

General Comments:

1. Groundwater at 1.2m after 20 minutes.
2. No visual or olfactory evidence of contamination.
3.

Scale:
Date: 09/03/2022
Logged by: AH
Checked: SW
Job No: R21071

Grange Geo Consulting Ltd

Hand Pit Log

HP No: **1**

Client: Kirk Homes Ltd
Project: Smithfield, Scoldhall Lane, Surfleet

Sheet: 1 of 1
Method: Hand Excavated

Sample Depth (m)	Sample Type	Testing result	Description	Depth mBGL	Legend
			Made Ground, brown, silty CLAY with rare ash.		
			Brown, slightly sandy, clayey, SAND.		
0.5					
			End of trial pit.		
1				1	

General Comments:

1. No groundwater encountered.
2. Rare ash noted in the Made Ground.
3. Hole backfilled.

Scale:
Date: 09/03/2022
Logged by: AH
Checked: SW
Job No: R21071

Grange Geo Consulting Ltd

Hand Pit Log

HP No: 2

Client: Kirk Homes Ltd
Project: Smithfield, Scoldhall Lane, Surfleet

Sheet: 1 of 1
Method: Hand Excavated

Sample Depth (m)	Type	Testing result	Description	Depth mBGL	Legend
			Made Ground, brown, slightly sandy, silty, CLAY.		
0.5					
				1	
1					

General Comments:

1. No groundwater encountered.
2. No visual or olfactory evidence of contamination encountered.
3. Hole backfilled.

Scale:
Date: 09/03/2022
Logged by: AH
Checked: SW
Job No: R21071

Grange Geo Consulting Ltd

Appendix D

GRANGE GEOCONSULTING LIMITED METHODOLOGY

RISK ASSESSMENT RATIONALE

The work presented in this report has been carried out in general accordance with recognised best practice as detailed in guidance documents such as in BS5930:1999 and BS10175:2001. Important aspects of the risk assessment process are transparency and justification. The rationale behind the risk assessments presented is given in this appendix.

A preliminary risk assessment is made of both geotechnical and geo-environmental hazards identified at the desk study stage and confirmed (or amended) at the ground investigation stage. This is based on a simple matrix of probability of occurrence versus the consequence, as explained below. In the case of geo-environmental hazards, the risk assessment process proceeds to the next level, the generic risk assessment, in which actual contaminant concentrations are considered.

Preliminary Risk Assessment (Geotechnical Risk Register)

The preliminary geotechnical risk register is compiled in accordance with the Highways Agency Design Manual for Roads and Bridges HD/02. This requires an estimation of the *probability* of an event happening multiplied by the *impact* or consequences of that event. Five levels of probability and impact are given scores, and these are multiplied to give a risk rating and a qualitative risk level is assigned as in Table A based on the terminology of Clayton (2001).

Table A: Geotechnical Risk Rating

Assessment of Geotechnical Risks (Risk Register)				
Probability (P)	**Impact (I)**	**Impact in terms of cost or time (% of construction cost or time)**	**Risk Rating (R = P x I)**	**Risk Level**
Very likely (5)	Very High (5)	>25%	17 to 25	Intolerable
Likely (4)	High (4)	10 to 25%	13 to 16	Intolerable
Probable (3)	Medium (3)	4 to 10%	9 to 12	Substantial
Unlikely (2)	Low (2)	1 to 4%	5 to 8	Tolerable
Negligible (1)	Very Low (1)	<1%	1 to 4	Trivial

Preliminary Risk Assessment (Geoenvironmental Consequences and Probability)

The Preliminary Risk Assessment includes a geo-environmental Hazard Identification, which seeks to list all the suspected contaminant **sources**, the **receptors** that might be harmed by those sources and the **pathways** via which the sources might reach the receptors to cause the harm. The source-pathway-receptor concept is known as a pollution linkage, and only when a linkage is complete is there any possibility of risk of harm arising.

The Hazard Identification evaluates all the **possible** pollution linkages in tabular form. Professional judgement is then used to evaluate which of these pollution linkages may be considered as **plausible**. Plausible pollution linkages are unacceptable risks in terms of the current contaminated land regime legal framework and require either remediation or further assessment. These are normally addressed via intrusive ground investigation and the chemical analysis of soil and water samples.

Where no plausible linkage identified, the linkage is classed as 'no linkage' in the summary table and no further action is required. If a linkage is plausible, a comparison is made of consequence against probability in general accordance with the guidance given in CIRIA Report C552 (Rudland *et al* 2001). Classification of consequences and probability are given in CIRIA C552 Tables 6.3 and 6.4, respectively, but there are

several inconsistencies in the original Table 6.3, in particular relating to 'significant harm or significant possibility of significant harm' (SH/SPOSH). Consequently, the table has been updated by Grange Geo in line with current practice and is given in Table B. Also added are scores from 1 to 4 for each category.

The basis of the classification is that 'severe' and 'major' are likely to result in SH/SPOSH as defined by the EPA 1990, Part 2A, with 'severe' resulting in acute harm. 'Moderate' lies below the level of SH/SPOSH but above the level of 'no harm' as implied by the relevant Generic assessment criterion (GAC, see below). Minor lies below the 'no harm' level.

Table B: Classification of Consequences of Geoenvironmental Risks

Classification of Consequences for Geoenvironmental Risks		
Classification	**Definition**	**Examples**
Severe (4 points)	Concentration of contaminants is likely to (or is known from previous data to) exceed that indicative of unacceptable intake or contact. I.e. >>SH/SPOSH, concentrations are high enough to cause acute (short-term) effects.	Human health: short-term (acute) effects likely to result in significant harm. E.g. high conc. of cyanide at the surface of an informal recreational area. Planting: complete and rapid die-back of landscaped areas. Controlled waters: short-term pollution, e.g. major spillage into controlled water. Buildings etc.: catastrophic damage, e.g. explosion causing collapse. Ecosystems: short-term risk to an ecosystem or organism forming part of that ecosystem in a designated protected area, e.g. by contamination spillage. Site workers: risk assessment required to determine PPE, and this may involve USEPA Level A, B or C protection.
Major (3 points)	Concentration of contaminants is likely to (or is known from previous data to) exceed that indicative of unacceptable intake or contact. I.e. >SH/SPOSH.	Human health: long-term (chronic) effects likely to result in significant harm. E.g. high conc. of contaminants close to the surface of a development site. Planting: stressed or dead plants in landscaped areas. Controlled waters: pollution of sensitive water resources, e.g. leaching into major or minor aquifers or rivers. Buildings etc.: damage renders unsafe to occupy. Ecosystems: death of species in an ecosystem in a designated protected area, e.g. by contamination spillage. Site workers: risk assessment required to determine PPE, and this may involve USEPA Level B, C or D protection.

Classification of Consequences for Geoenvironmental Risks		
Classification	**Definition**	**Examples**
Moderate (2 points)	Concentration of contaminants is likely to (or is known from previous data to) exceed that indicative of no harm but not unacceptable intake or contact. I.e. >SVG/GAC but <SH/SPOSH.	Human health: harm but probably not significant harm unless particularly sensitive individual within the receptor group. May be aesthetic/olfactory impacts. Planting: damage to plants in landscaped areas, e.g. stunted growth, discoloration. Controlled waters: pollution of non-sensitive water bodies e.g. leaching into non-classified groundwater or minor ditches. Buildings etc.: damage to sensitive buildings etc. Ecosystems: minor change in an ecosystem in a designated protected area, but not significant harm. Site workers: risk assessment required to determine PPE, and this may involve USEPA Level C or D protection.
Minor (1 point)	Concentration of contaminants is likely to (or is known from previous data to) be less than that indicative of no harm. I.e. <SGV/GAC.	No measurable effects, but simple PPE required (USEPA Level D protection, i.e. overalls, boots, goggles, hard hat).

CIRIA Table 6.4 is reproduced as Table C below, but also with the addition of scores from 1 to 4. This provides an estimate of the probability that the event described by the pollution linkage will occur. For example, the likelihood that pollution of groundwater will occur by leaching of metals into the aquifer.

Table C: Classification of Probability of Geoenvironmental Risks

Classification of Probability of Geoenvironmental Risks	
Classification	**Definition**
High (4 points)	There is a pollution linkage and 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.
Medium (3 points)	There is a pollution linkage and all the elements are present and in the right place, which means that it is probable that an event will occur. Circumstances are such that an event in not inevitable, but possible in the short term and likely over the long term.
Low (2 points)	There is a pollution linkage and circumstances are possible under which an event could occur. However, it is no means certain that even over a longer period such event could take place and is less likely in the shorter term.
Unlikely (1 point)	There is a pollution linkage, but circumstances are such that it is improbable that an event would occur even in the very long term.

The perceived level of risk for each pathway is then derived from the probability versus consequences matrix, modified after CIRIA C552 Table 6.5, given in Table D. The scores are summed accordingly and the result assigned a risk level by dividing the range between the minimum score of 1 and the maximum score of 16 equally into 5 categories i.e. 1 to <4 is very low risk, 4 to <7 is low risk, 7 to <10 is moderate risk, 10 to <13 is high risk and 13 to 16 is very high risk.

Table D: Qualitative Risk Level from Consequence and Probability

		Consequence			
	product	**Severe (4)**	**Major (3)**	**Moderate (2)**	**Minor (1)**
Probability	**High (4)**	16 = Very high risk	12 = High risk	8 = Moderate risk	4 = Low risk
	Medium (3)	12 = High risk	9 = Moderate risk	6 = Low risk	3 = Very low risk
	Low (2)	8 = Moderate risk	6 = Low risk	4 = Low risk	2 = Very low risk
	Unlikely (1)	4 = Low risk	3 = Very low risk	2 = Very low risk	1 = Very low risk

This approach assumes an equivalence between probability and consequences and ignores the difficulty that can arise where to probability of occurrence appears to be almost negligible, but the consequences are very severe. In such conditions, there is a degree of subjectivity in assessing the level of risk and it could be low, moderate or high. Such risks may require specialist consideration beyond the scope of this standard report.

A description of the classified risks and the likely action required can be determined from Table E.

Table E: Description of the Classified Risks and Likely Action Required

Description of Classified Risks and Likely Action Required	
Very High Risk	A significant pollution linkage, including actual evidence of significant harm or significant possibility and significant harm, is clearly identifiable at the site (e.g. from visual or documentary evidence) under current conditions, with potential for legal and/or financial consequences for the site owner or other Responsible Person. Remediation advisable based on acute impacts being likely. Immediate action should be considered.
High Risk	A pollution linkage is identifiable at the site under current and future use conditions. Although likely, there is no obvious actual evidence of significant harm or significant possibility and significant harm under current conditions. Extent of risk is therefore subject to confirmation by investigation and risk assessment and most likely to be deemed significant. Remediation required for redevelopment and may also be required under Part 2A for existing receptors.
Moderate Risk	A pollution linkage is identifiable at the site under current and future use conditions. However, it is not likely to be a significant linkage under current conditions. Actual extent of risk subject to confirmation by additional investigation and risk assessment and most likely to lie between no possibility of harm (under current conditions) and significant possibility of significant harm (under conditions created by new use). Remediation may be required for redevelopment.
Low risk	Potential pathways and receptors exist but history of contaminative use or site conditions indicates that contamination is likely to be of limited extent and below the level of no possibility of harm. Precautionary investigations and risk assessment advisable on change of use.
Very Low Risk	No pollution linkage likely to exist under current or future conditions. Site not capable of being determined under Part 2A (in accordance with PPS23) where the Local Authority inspects the site. No further action recommended.

Contaminant Analysis of Samples

CLR 8 (Environment Agency 2002b), the DoE Industry Profile documents and ISO10381-5 provide good summaries of priority pollutants for UK sites. Additionally, the Environment Agency has produced a list of priority pollutants for ecological risk assessment in a consultation document (Environment Agency 2003a). These documents have been used, with the findings of the Phase 1 investigation, to scope the analyses of chemicals of potential concern.

Grange Geo considers there to be a minimum requirement for soil chemical analysis, even for Greenfield sites, to satisfy the 'suitable for use' criterion of the planning regime. The GACs adopted by Grange Geo for the Site are given in the following table.

There is no safe acceptable level for asbestos in soils, detect or non-detect is recorded with asbestos quantification undertaken on samples found to contain asbestos.

The tables below for the derivation of Generic Criteria for the **Public Open Spaces** Standard Land Use. This is a very conservative land use criteria given the use of the site for commercial use as a farm shop yard / office with exterior gravel yard areas and permeable paving.

Table F: Generic Assessment Criteria (GAC) for Public Open Spaces (Resi)

Based on a 1% Soil Organic Matter Content (most conservative approach)

Based on SGVs, C4SL and S4UL values

Heavy Metals	
Cyanide	5
Arsenic	79
Beryllium	2.2
Boron	21,000
Cadmium	120
Chromium	1,500
Chromium VI	7.7
Copper	12,000
Lead	630
Mercury (elemental)	16
Mercury (inorganic)	120
Nickel	230
Selenium	1,100
Vanadium	2,000
Zinc	81,000
BTEX	
Benzene	72
Toluene	56,000
Ethyl Benzene	17,000
m/p Xylenes	17,000
o Xylenes	17,000
Xylenes	17,000
Speciated PAHs	
Naphthalene	1,200

Acenaphthylene	15,000
Acenaphthene	15,000
Fluorene	9,900
Phenanthrene	3,100
Anthracene	74,000
Fluoranthene	3,100
Pyrene	7,400
Benzo[a]anthracene	29
Chrysene	57
Benzo[b]fluoranthene	7.1
Benzo[k]fluoranthene	190
Benzo[a]pyrene	5.7
Indeno[123-cd]pyrene	82
Dibenzo[ah]anthracene	0.57
Benzo[ghi]perylene	640
Asbestos	
Asbestos	Non-detected

Appendix E

CONTAMINANT DATA (PENDAMETHALIN)

Safety Data Sheet
acc. to OSHA HCS

Printing date 03/24/2019 Version Number 3 Reviewed on 03/24/2019

*
1 Identification

· **Product identifier**

· **Trade name: Pendimethalin**

· **Part number:** PST-1600, PST-1600-10MG, PST-1600-25MG, PST-1600-50MG
· **CAS Number:**
40487-42-1
· **EC number:**
254-938-2
· **Index number:**
609-042-00-X
· **Application of the substance / the mixture** Reagents and Standards for Analytical Chemical Laboratory Use

· **Details of the supplier of the safety data sheet**
· **Manufacturer/Supplier:**
Agilent Technologies, Inc.
5301 Stevens Creek Blvd.
Santa Clara, CA 95051 USA

· **Information department:**
Telephone: 800-227-9770
e-mail: pdl-msds_author@agilent.com
· **Emergency telephone number:** CHEMTREC®: 1-800-424-9300

*
2 Hazard(s) identification

· **Classification of the substance or mixture**



GHS07

Acute Tox. 4 H302 Harmful if swallowed.
Skin Sens. 1 H317 May cause an allergic skin reaction.

· **Label elements**
· **GHS label elements** The substance is classified and labeled according to the Globally Harmonized System (GHS).
· **Hazard pictograms**



GHS07

· **Signal word** Warning

· **Hazard-determining components of labeling:**
pendimethalin (ISO)
· **Hazard statements**
Harmful if swallowed.
May cause an allergic skin reaction.
· **Precautionary statements**
Avoid breathing dust/fume/gas/mist/vapors/spray
Wash thoroughly after handling.
Do not eat, drink or smoke when using this product.
Contaminated work clothing must not be allowed out of the workplace.
Wear protective gloves.

(Contd. on page 2)

Safety Data Sheet
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Printing date 03/24/2019 Version Number 3 Reviewed on 03/24/2019

Trade name: Pendimethalin

(Contd. of page 1)

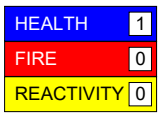
If swallowed: Call a poison center/doctor if you feel unwell.
Rinse mouth.
If on skin: Wash with plenty of water.
If skin irritation or rash occurs: Get medical advice/attention.
Specific treatment (see on this label).
Wash contaminated clothing before reuse.
Dispose of contents/container in accordance with local/regional/national/international regulations.

· **Classification system:**
· **NFPA ratings (scale 0 - 4)**



Health = 1
Fire = 0
Reactivity = 0

· **HMIS-ratings (scale 0 - 4)**



Health = 1
Fire = 0
Reactivity = 0

· **Other hazards**
· **Results of PBT and vPvB assessment**
· **PBT:** Not applicable.
· **vPvB:** Not applicable.

3 Composition/information on ingredients

· **Chemical characterization: Substances**
· **CAS No. Description**
40487-42-1 pendimethalin (ISO)
· **Identification number(s)**
· **EC number:** 254-938-2
· **Index number:** 609-042-00-X

*
4 First-aid measures

· **Description of first aid measures**
· **General information:**
Symptoms of poisoning may even occur after several hours; therefore medical observation for at least 48 hours after the accident.
· **After inhalation:**
Supply fresh air and to be sure call for a doctor.
In case of unconsciousness place patient stably in side position for transportation.
· **After skin contact:** Immediately wash with water and soap and rinse thoroughly.
· **After eye contact:** Rinse opened eye for several minutes under running water.
· **After swallowing:** Immediately call a doctor.
· **Information for doctor:**
· **Most important symptoms and effects, both acute and delayed** No further relevant information available.

(Contd. on page 3)

Safety Data Sheet
acc. to OSHA HCS

(Contd. of page 2)

· **Indication of any immediate medical attention and special treatment needed**
No further relevant information available.

5 Fire-fighting measures

· **Extinguishing media**
· **Suitable extinguishing agents:** Use fire fighting measures that suit the environment.
· **Special hazards arising from the substance or mixture** No further relevant information available.
· **Advice for firefighters**
· **Protective equipment:** No special measures required.

6 Accidental release measures

· **Personal precautions, protective equipment and emergency procedures** Not required.
· **Environmental precautions:** Do not allow to enter sewers/ surface or ground water.
· **Methods and material for containment and cleaning up:**
Dispose contaminated material as waste according to item 13.
Ensure adequate ventilation.
· **Reference to other sections**
See Section 7 for information on safe handling.
See Section 8 for information on personal protection equipment.
See Section 13 for disposal information.
· **Protective Action Criteria for Chemicals**

· **PAC-1:**
Substance is not listed.

· **PAC-2:**
Substance is not listed.

· **PAC-3:**
Substance is not listed.

7 Handling and storage

· **Handling:**
· **Precautions for safe handling** Ensure good ventilation/exhaustion at the workplace.
· **Information about protection against explosions and fires:** No special measures required.

· **Conditions for safe storage, including any incompatibilities**
· **Storage:**
· **Requirements to be met by storerooms and receptacles:** No special requirements.
· **Information about storage in one common storage facility:** Not required.
· **Further information about storage conditions:** None.
· **Specific end use(s)** No further relevant information available.

*
8 Exposure controls/personal protection

· **Additional information about design of technical systems:** No further data; see item 7.

(Contd. on page 4)

(Contd. of page 3)

· **Control parameters**
· **Components with limit values that require monitoring at the workplace:**
The following constituent is the only constituent of the product which has a PEL, TLV or other recommended exposure limit.
The following constituents are the only constituents of the product which have a PEL, TLV or other recommended exposure limit.
At this time, the remaining constituent has no known exposure limits.
At this time, the other constituents have no known exposure limits.
· **Additional information:** The lists that were valid during the creation were used as basis.

· **Exposure controls**
· **Personal protective equipment:**
· **General protective and hygienic measures:**
Keep away from foodstuffs, beverages and feed.
Immediately remove all soiled and contaminated clothing.
Wash hands before breaks and at the end of work.
· **Breathing equipment:**
When used as intended with Agilent instruments, the use of the product under normal laboratory conditions and with standard practices does not result in significant airborne exposures and therefore respiratory protection is not needed.
Under an emergency condition where a respirator is deemed necessary, use a NIOSH or equivalent approved device/equipment with appropriate organic or acid gas cartridge.
· **Protection of hands:**
Although not recommended for constant contact with the chemicals or for clean-up, nitrile gloves 11-13 mil thickness are recommended for normal use. The breakthrough time is 1 hr. For cleaning a spill where there is direct contact of the chemical, butyl rubber gloves are recommended 12-15 mil thickness with breakthrough times exceeding 4 hrs. Supplier recommendations should be followed.
· **Material of gloves**
For normal use: nitrile rubber, 11-13 mil thickness
For direct contact with the chemical: butyl rubber, 12-15 mil thickness
The selection of the suitable gloves does not only depend on the material, but also on further marks of quality and varies from manufacturer to manufacturer.
· **Penetration time of glove material**
For normal use: nitrile rubber: 1 hour
For direct contact with the chemical: butyl rubber: >4 hours
· **Eye protection:** Not required.

*
9 Physical and chemical properties

· **Information on basic physical and chemical properties**	
· **General Information**	
· **Appearance:**	
Form:	Crystalline
Color:	Not determined.
· **Odor:**	Odorless
· **Odor threshold:**	Not determined.
· **pH-value:**	Not applicable.
· **Change in condition**	
Melting point/Melting range:	56-57 °C (132.8-134.6 °F)

(Contd. on page 5)

(Contd. of page 4)

Boiling point/Boiling range:	Undetermined.
· **Flash point:**	Not applicable.
· **Flammability (solid, gaseous):**	Product is not flammable.
· **Decomposition temperature:**	Not determined.
· **Auto igniting:**	Not determined.
· **Danger of explosion:**	Product does not present an explosion hazard.
· **Explosion limits:**	
Lower:	Not determined.
Upper:	Not determined.
· **Vapor pressure at 20 °C (68 °F):**	0.00008 hPa (0 mm Hg)
· **Density:**	Not determined.
· **Relative density**	Not determined.
· **Vapor density**	Not applicable.
· **Evaporation rate**	Not applicable.
· **Solubility in / Miscibility with**	
Water:	Insoluble.
· **Partition coefficient (n-octanol/water):**	Not determined.
· **Viscosity:**	
Dynamic:	Not applicable.
Kinematic:	Not applicable.
VOC content:	0.00 % 0.0 g/l / 0.00 lb/gal
Solids content:	100.0 %
· **Other information**	No further relevant information available.

10 Stability and reactivity

· **Reactivity** No further relevant information available.
· **Chemical stability**
· **Thermal decomposition / conditions to be avoided:** No decomposition if used according to specifications.
· **Possibility of hazardous reactions** No dangerous reactions known.
· **Conditions to avoid** No further relevant information available.
· **Incompatible materials:** No further relevant information available.
· **Hazardous decomposition products:** No dangerous decomposition products known.

*

11 Toxicological information

· **Information on toxicological effects**
· **Acute toxicity:**

· **LD/LC50 values that are relevant for classification:**		
ATE (Acute Toxicity Estimate)		
Oral	LD50	1,050 mg/kg (rat)
Dermal	LD50	2,260 mg/kg (rabbit)

(Contd. on page 6)

Safety Data Sheet
acc. to OSHA HCS

Printing date 03/24/2019 Version Number 3 Reviewed on 03/24/2019

Trade name: Pendimethalin

(Contd. of page 5)

40487-42-1 pendimethalin (ISO)		
Oral	LD50	1,050 mg/kg (rat)
Dermal	LD50	2,260 mg/kg (rabbit)

· **Primary irritant effect:**
· **on the skin:** No irritant effect.
· **on the eye:** No irritating effect.
· **Sensitization:** Sensitization possible through skin contact.
· **Additional toxicological information:**

· **Carcinogenic categories**

· IARC (International Agency for Research on Cancer)
Substance is not listed.

· NTP (National Toxicology Program)
Substance is not listed.

· OSHA-Ca (Occupational Safety & Health Administration)
Substance is not listed.

12 Ecological information

· **Toxicity**
· **Aquatic toxicity:** No further relevant information available.
· **Persistence and degradability** No further relevant information available.
· **Behavior in environmental systems:**
· **Bioaccumulative potential** No further relevant information available.
· **Mobility in soil** No further relevant information available.
· **Additional ecological information:**
· **General notes:**
Water hazard class 2 (Self-assessment): hazardous for water
Do not allow product to reach ground water, water course or sewage system.
Danger to drinking water if even small quantities leak into the ground.
· **Results of PBT and vPvB assessment**
· **PBT:** Not applicable.
· **vPvB:** Not applicable.
· **Other adverse effects** No further relevant information available.

13 Disposal considerations

· **Waste treatment methods**
· **Recommendation:**
Must not be disposed of together with household garbage. Do not allow product to reach sewage system.

· **Uncleaned packagings:**
· **Recommendation:** Disposal must be made according to official regulations.

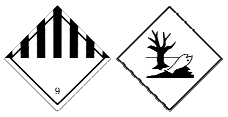
(Contd. on page 7)

Safety Data Sheet
acc. to OSHA HCS

(Contd. of page 6)

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14 Transport information

· **UN-Number**	
· **DOT, IMDG, IATA**	UN3077
· **UN proper shipping name**	
· **DOT**	Environmentally hazardous substance, solid, n.o.s. (pendimethalin (ISO))
· **IMDG, IATA**	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, SOLID, N.O.S. (pendimethalin (ISO))
· **Transport hazard class(es)**	
· **DOT, IMDG**	
· **Class**	9 Miscellaneous dangerous substances and articles
· **Label**	9
· **IATA**	
· **Class**	9 Miscellaneous dangerous substances and articles
· **Label**	9
· **Packing group**	
· **DOT, IMDG, IATA**	III
· **Environmental hazards:**	
· **Special marking (IATA):**	Symbol (fish and tree)
· **Special precautions for user**	Warning: Miscellaneous dangerous substances and articles
· **Danger code (Kemler):**	90
· **EMS Number:**	F-A,S-F
· **Stowage Category**	A
· **Stowage Code**	SW23 When transported in BK3 bulk container, see 7.6.2.12 and 7.7.3.9.
· **Transport in bulk according to Annex II of MARPOL73/78 and the IBC Code**	Not applicable.
· **Transport/Additional information:**	
· **DOT**	
· **Quantity limitations**	On passenger aircraft/rail: No limit On cargo aircraft only: No limit
· **IMDG**	
· **Limited quantities (LQ)**	5 kg

(Contd. on page 8)

Safety Data Sheet
acc. to OSHA HCS

Trade name: Pendimethalin

(Contd. of page 7)

· **Excepted quantities (EQ)**	Code: E1 Maximum net quantity per inner packaging: 30 g Maximum net quantity per outer packaging: 1000 g
· **UN "Model Regulation":**	UN 3077 ENVIRONMENTALLY HAZARDOUS SUBSTANCE, SOLID, N.O.S. (PENDIMETHALIN (ISO)), 9, III

*
15 Regulatory information

· **Safety, health and environmental regulations/legislation specific for the substance or mixture**
· **Sara**

· **Section 355 (extremely hazardous substances):**
Substance is not listed.

· **Section 313 (Specific toxic chemical listings):**
Substance is listed.

· **TSCA (Toxic Substances Control Act):**
Substance is not listed.

· **TSCA new (21st Century Act): (Substances not listed)**

40487-42-1	pendimethalin (ISO)

· **Proposition 65**

· **Chemicals known to cause cancer:**
Substance is not listed.

· **Chemicals known to cause reproductive toxicity for females:**
Substance is not listed.

· **Chemicals known to cause reproductive toxicity for males:**
Substance is not listed.

· **Chemicals known to cause developmental toxicity:**
Substance is not listed.

· **Carcinogenic categories**

· **EPA (Environmental Protection Agency)**
Substance is not listed.

· **TLV (Threshold Limit Value established by ACGIH)**
Substance is not listed.

· **NIOSH-Ca (National Institute for Occupational Safety and Health)**
Substance is not listed.

· **Chemical safety assessment:** A Chemical Safety Assessment has not been carried out.

16 Other information

The information contained in this document is based on Agilent's state of knowledge at the time of preparation. No warranty as to its accurateness, completeness or suitability for a particular purpose is expressed or implied.

· **Department issuing SDS:** Document Control / Regulatory
· **Contact:** regulatory@ultrasci.com

(Contd. on page 9)

Safety Data Sheet
acc. to OSHA HCS

Trade name: Pendimethalin

(Contd. of page 8)

· **Date of preparation / last revision** 03/24/2019 / 2

· **Abbreviations and acronyms:**

ADR: Accord européen sur le transport des marchandises dangereuses par Route (European Agreement concerning the International Carriage of Dangerous Goods by Road)
IMDG: International Maritime Code for Dangerous Goods
DOT: US Department of Transportation
IATA: International Air Transport Association
ACGIH: American Conference of Governmental Industrial Hygienists
EINECS: European Inventory of Existing Commercial Chemical Substances
CAS: Chemical Abstracts Service (division of the American Chemical Society)
NFPA: National Fire Protection Association (USA)
HMIS: Hazardous Materials Identification System (USA)
VOC: Volatile Organic Compounds (USA, EU)
LC50: Lethal concentration, 50 percent
LD50: Lethal dose, 50 percent
PBT: Persistent, Bioaccumulative and Toxic
vPvB: very Persistent and very Bioaccumulative
NIOSH: National Institute for Occupational Safety
OSHA: Occupational Safety & Health
TLV: Threshold Limit Value
PEL: Permissible Exposure Limit
REL: Recommended Exposure Limit
Acute Tox. 4: Acute toxicity – Category 4
Skin Sens. 1: Skin sensitisation – Category 1

· *** Data compared to the previous version altered.**

MEMORANDUM

SUBJECT: EFED Science Chapter for Pendimethalin (Case # 0817)

FROM: C. Renée Costello, Task Team Leader
Environmental Risk Characterization Branch
Environmental Fate and Effects Division (7507C)

THRU: Elizabeth M. Leovey, Chief
Environmental Risk Characterization Branch
Environmental Fate and Effects Division (7507C)

TO: Jane Mitchell, CRM Team Reviewer
Sherell Sterling, Team Leader
Special Review and Reregistration Division (7508W)

Attached to this memorandum is the EFED Reregistration Eligibility Decision (RED) Science Chapter (Attachment 1) for pendimethalin. The EFED Science Chapter, which can be directly merged into the RED document, contains the environmental assessment divided into four sections: Environmental Fate and Transport; Ecological Effects; Ecological Exposure and Risk Assessment; and Environmental Risk Characterization. Attachment 2 is the physicochemical data for amitrole and the DERs for the environmental fate and transport guideline studies. Attachment 3 is the Groundwater Assessment.

Pendimethalin is a dinitroaniline herbicide registered for use on annual grasses and broadleaf weeds in terrestrial food crop and terrestrial non-food crop use groups. It is a cell growth inhibitor that prevents seedling development and is herbicidally active on the roots and coleoptiles of susceptible weeds. Pendimethalin does not control weeds postemergence and must be soil applied. Formulations include a 3.3 emulsifiable concentrate, a 4.0 emulsifiable concentrate, a 60DG water dispersible granule, and a fertilizer formulation. Application rates range from 1.0 to 4.0 lbs ai/A. Total pendimethalin use ranges from 14 to 25 million pounds active ingredient annually, with the largest usage occurring on soybeans, cotton, and corn.

Environmental Risk Characterization Conclusions:

- Pendimethalin dissipates in the environment by binding to soil, microbially-mediated metabolism and volatilization. It is essentially immobile in soil.

- Based on laboratory studies and limited field study information, pendimethalin is slightly to moderately persistent in aerobic soil environments. Persistence decreases with increased temperature, increased moisture and decreased soil organic carbon.

- Additional terrestrial field dissipation studies for major pendimethalin uses (cotton and soybeans) are requested to fully characterize the fate of pendimethalin.

- Pendimethalin may contaminate surface water from spray drift associated with aerial and ground spray application, or in runoff from rainfall events and through irrigation waters (chemigation). However, the high affinity for pendimethalin to bind to soil and sediment particles should limit concentrations of pendimethalin in surface waters.

- Although pendimethalin has been detected in ground water (at very low levels), the potential for ground water contamination from pendimethalin residues is low.

- Pendimethalin would not represent a high acute risk to birds or a high acute or chronic risk to mammals. The chronic risk to birds could not be determined because avian reproduction studies have not been submitted. These studies are requeted.

- Chronic risk LOCs for fish were exceeded by a small margin. But it is presumed that overall, pendimethalin does not represent a high risk to aquatic animals and plants, including estuarine organisms.

- The use of pendimethalin may adversely effect endangered species of terrestrial and semi-aquatic plants, aquatic plants and invertebrates including mollusks, fish, and birds (specifically grazers).

- The risk to nontarget terrestrial and semi-aquatic plants is expected to be moderate. However any impact to floral communities, should it occur, could be extensive because of the high poundage used.

Recommendations

1. Avian Reproduction studies (71-4) preferably with a bobwhite quail and a mallard duck are requested on the technical grade of the active ingredient.

An avian chronic risk assessment cannot be completed without these studies. Pendimethalin has been shown to be persistent in both field and laboratory studies. It has a high potential to bioaccumulate in fish. Pendimethalin is a widely used agrochemical with up to 25 million pounds active ingredient per year applied nationwide. According to the label, several applications may be applied per use

season for most major crops, including cotton and rice.

2. Additional terrestrial field dissipation studies (164-1) for major use sites (cotton and soybeans) uses under typical use conditions are requested.

Only one terrestrial field study for pendimethalin has been submitted (almond site in California). The field dissipation results from this site would not be characteristic of major use sites such as cotton and soybeans. These studies will provide information on dissipation routes and potential for off-site drift.

The study design should incorporate air sampling. The depth of sampling can be limited to 12 inches. ERCB is willing to work with the registrant to develop the study design.

3. Aquatic field dissipation (GLN 164-2) is unsatisfied at this time since no study has been submitted to the agency. However, the registrant has conducted an aquatic field dissipation study in dry-seeded rice in Arkansas that has not yet been submitted.

4. Droplet size spectrum (GLN 201-1) and drift field evaluation (GLN 202-1) studies are required for pendimethalin, since the different formulations may be applied by aircraft and it is estimated that there will be detrimental effects to non-target terrestrial and semi-aquatic plants due to drift. However, to satisfy these requirements the registrant, in conjunction with other registrants of other pesticide active ingredients, formed the Spray Drift Task Force (SDTF).

5. EFED does not recommend any risk reduction measures at this time.

Labeling Requirements and Endangered Species

All pesticides with outdoor, terrestrial uses are required to have the following statement in the Environmental Hazards section of the label:

"This pesticide is toxic to fish and aquatic invertebrates. Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high water mark."

When the Endangered Species Protection Program becomes final, limitations in the use of pendimethalin may be required to protect endangered and threatened species, but these limitations have not been defined and may be formulation specific. EPA anticipates that a consultation with the Fish and Wildlife Service may be conducted in accordance with the species-based priority approach described in the Program. After completion of consultation, registrants will be informed if any required label modifications are necessary. Such modifications would most likely consist of the generic label statement referring pesticide users to use limitations contained in county Bulletins.

ERCB TASK TEAM MEMBERS:

C. Renée Costello (Task leader and Ecological Effects Assessment)	Biologist, ERCB/EFED
James A. Breithaupt (Environmental Fate Assessment)	Agronomist, ERCB/EFED
David Wells (Ground Water Assessment)	Hydrologist, ERCB/EFED
William R. Effland (Surface Water Assessment) (Peer Review)	Soil Scientist, ERCB/EFED
Andrew Bryceland (Peer Review)	Biologist, ERCB/EFED

Attachments

Electronic copies (via cc:Mail):

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C. Environmental Assessment

The environmental assessment consists of four sections: Environmental Fate; Ecological Toxicity; Ecological Exposure and Risk Assessment; and Environmental Risk Characterization. The first section depicts the environmental fate and transport data from field and laboratory studies, analyzes the impact to water resources, and details the environmental fate assessment. The second and third sections report the ecological toxicity data from laboratory studies, estimates ecological exposure and assesses the effects to nontarget terrestrial and aquatic organisms. The section on environmental risk characterization integrates the exposure and effects assessments to determine the extent and potential for risk to the environment.

1. Environmental Fate

a. Environmental Fate Assessment

Pendimethalin dissipates in the environment by binding to soil, microbially-mediated metabolism, and volatilization. Persistence decreases with increased temperature, increased moisture and decreased soil organic carbon. Pendimethalin residues are tightly bound to soil and sediment particles. Field dissipation information on the major use sites (cotton and soybeans) that would more clearly describe the environmental fate of pendimethalin has not been submitted.

Pendimethalin is stable to sterile hydrolysis, soil photolysis, and anaerobic soil metabolism, but degrades slowly under aqueous photolysis conditions with a calculated half-life of 21 days. Aerobic soil metabolism half-lives range from 42-1322 days with 172 days used for the purpose of exposure assessment. Pendimethalin forms many minor (<10% of applied) degradates that are primarily an intact benzene ring with rearranged alkyl groups. Anaerobic aquatic metabolism half-lives ranged from 6 to 105 days. Aqueous residues of parent pendimethalin and its degradates bind to sediment in anaerobic aquatic metabolism and soil mobility studies. This is consistent with mobility studies indicating that pendimethalin is essentially immobile in all soils studied.

The calculated half-life of pendimethalin in a field study (almond orchard in California) was 34 days. Although the orchard site is not a major use site for pendimethalin, the resulting half-life is consistent with the results from the soil metabolism studies.

Pendimethalin accumulated readily in bluegill sunfish with BCFs of 1400X in edible, 5800X in non-edible and 5100X in whole fish, however, depuration was rapid.

Pendimethalin may contaminate surface water from spray drift associated with aerial and ground spray application, or in runoff from rainfall events and through irrigation waters (chemigation). However, the high affinity for pendimethalin to sorb to soil and sediment particles should limit concentrations of pendimethalin in surface waters. Pendimethalin was

detected in surface water samples at a maximum of 3.66 µg/L in selected Lower Great Lake Tributaries during 1982-1985. In a study of the spatial and temporal distributions of pesticides and nutrients in the Mississippi River and its tributaries, dissolved pendimethalin was not detected in surface water sample above the reporting limit of 0.018 µg/l. Surface water monitoring results found in the STORET database are a compilation of various states' monitoring data. The maximum concentration of pendimethalin was 17.6 µg/L (ppb) for a surface water sample collected in Ohio; the next highest reported concentration was 10 µg/L with a range of 1-10 µg/L. From the STORET data (excluding the highest Ohio sampling results), the maximum concentrations of pendimethalin in surface water samples range from 0.01 to 3.2 µg/L.

Pendimethalin has a low potential to leach to ground water in most soils. Pendimethalin has a history of high use over a wide geographic area on several major crops, however, EFED has few reports of detections in ground water. Residues of pendimethalin have been found in ground water in limited areas in two states. The concentrations in ground water were relatively low, ranging from 0.2 to 0.9 ppb.

b. Environmental Fate and Transport

(1) Degradation

Abiotic Hydrolysis

Pendimethalin did not degrade in sterile aqueous buffer solutions (pH 5, 7, and 9) that were incubated in darkness at 25ºC for 30 days. The guideline requirement (GLN 161-1) is fulfilled. MRID 00106777

Abiotic and Biotic Hydrolysis

Calculated half-lives were 10-11 days (average of 10.6 days) in water containing different soil fungi and 354 days in sterile water. Three degradates were formed, which were ring rearrangements and ring additions. Zimdahl et al., 1990.

Photodegradation in Water

The calculated half-lives were 16.5 days at pH 5, 7, and 9 (MRID 43808201), and in an older study, 21 days at pH 7 (MRID 00153763). When corrected for the distance between the light source and the water in the most recent study (40 cm vs 80 cm for the older study), the 3.5 day half-life reported by the registrant becomes 16.5 days, which is consistent with the 21-day half-life in the older study. The artificial light intensity for the new study was for September 13, 1990 at Princeton, New Jersey and Chicago, Illinois on June 30 and the temperature was set at 25ºC. Up to 37 minor degradates were isolated, but only one degradate was identified, 2,6-dinitro-3,4-dimethyl aniline (a ring-rearrangement of parent pendimethalin with an ethylpropyl group removed from an amine group). However, the

degradate did not exceed 9.3% of applied, and no other degradate reached this amount. Pendimethalin was stable in the dark controls, which is consistent with the hydrolysis study. The guideline requirement (GLN 161-2) is fulfilled. MRIDs 00153763;43808201

Photodegradation on Soil

Pendimethalin did not degrade on sandy loam exposed to artificial light at 25ºC. The guideline requirement (GLN 161-3) is fulfilled. MRID 00153764.

Photolysis in Air

This study is not required because pendimethalin is tightly bound to soil and its toxicity is in Class 3. Gln. 161-4, waived on 6/27/91.

Aerobic Soil Metabolism

Pendimethalin degraded with a calculated half-life of 1322 days in sandy loam soil in a study submitted for registration. This half-life was considered an outlier and was not used in assessing the environmental fate of pendimethalin. The identified minor degradates were 2,6-dinitro-3,4-xylidine, 4-[(1-ethylpropyl)amino]-2-methyl-3,5-dinitro benzyl alcohol, and 4-[(1-ethylpropyl)amino]-3,5-dinitro-o-toluic acid. All of these degradates were ring rearrangements of parent pendimethalin.

The half-lives for aerobic soil metabolism ranged from 42-563 days in the literature studies referenced below with a guideline study reporting a half-life of 1322 days for a total of 27 total observations. Because of the range of values, statistical analyses of the available data were performed. The mean, median, and modal half-lives are 126, 122, and 122 days, respectively, with a standard deviation of 66 days (n=24). The half life values of 409, 563, and 1322 days were not included in the final statistical analyses because they were greater than three standard deviations from the mean. Based on soils and crops that are normally treated with pendimethalin, the reviewer assumed that temperatures would likely range from 20-30ºC and soil moisture contents from 50-75% Field Capacity (FC). The range of observed half-lives in the above experimental conditions were 72-172 days. The 172-day half-life was used for GENEEC calculations since it was the longest half-life for the observed range. Although some of the studies were conducted using foreign soils, the half-lives for foreign soils fall within the range of values seen in studies using U.S. soils. Gln. 162-1, MRID 40185104.

Half lives were affected by study conditions. Walker and Bond (1977) evaluated the effect of moisture, temperature and different soils on soil persistence.

As indicated in Table 1, persistence decreased about 5 days for every one percent increase in moisture.

Table 1. Calculated Half-Lives of Parent Pendimethalin in Sheeps Pen Loam Soil (1.2% OC, 18.3% clay) at 25ºC (Walker and Bond, 1977).

% Moisture (Field Capacity, **FC**)	Half-Life (days)
12.5	563
25	261
37.5	225
50	239
62.5	166
75	122

As indicated in Table 2 below, persistence decreased about 15 days for every degree of temperature increase.

Table 2. Calculated Half-Lives of Parent Pendimethalin in Sheeps Pen Loam Soil (1.2 % OC, 18.3 % clay) at 75 % Field Capacity (Walker and Bond, 1977).

Temperature (ºC)	Half-life (days)
30	98
25	122
20	168
15	265
10	409

As indicated in Table 3 below, the persistence of pendimethalin generally increased with increasing soil organic carbon and clay content.

Table 3. Half-Lives of Parent Pendimethalin in Different Soils at 25ºC and 75% FC (Walker and Bond, 1977).

Soil *	% OC	% clay	Half-life (days)
Soakwaters	0.87%	27.6%	72
Gravel Pits	1.08%	20.4%	87
Gallas Leys	1.12%	37.8%	132
Sheeps Pen	1.2%	18%	129
Big Cherry	1.33%	20%	139
Pump Ground	1.75%	20.5%	127
Water Meadows	6.8%	60.4%	172

* Incomplete soil characterization information was provided.

The following aerobic soil metabolism half-lives are from Zimdahl, et al., 1984:

Table 4. Calculated Half-Lives of Parent Pendimethalin in Different Soils (Zimdahl, et al., 1984).

Soil	% OC	% FC	Temperature (ºC)	Half-Life (days)
Clay loam	0.76%	50%	30	73
Clay loam	0.76%	75%	35	61
Clay loam	0.76%	75%	30	54
Clay loam	0.76%	75%	20	77
Clay loam	0.76%	75%	10	101
Clay loam	0.76%	100%	30	56
Clay	1.0%	75%	30	42
Sandy loam	0.76%	75%	30	45

In a study by Zimdahl, et al., as shown in Table 4, persistence generally increased with increasing clay and organic carbon content. The calculated half-lives were 42-101 days in a range of soils with 0.76 and 1.0% Organic Content (OC) at 50-100% Field Capacity (FC) and 10-35ºC. Persistence decreased with increasing moisture and temperature.

Anaerobic Soil Metabolism

Pendimethalin is stable to anaerobic soil metabolism. Ninety-eight percent of parent remained after 60 days of anaerobic conditions. The identified minor degradates were 2,6-dinitro-3,4-xylidine, 4-[(1-ethylpropyl)amino]-2-methyl-3,5-dinitro benzyl alcohol, and 4-

[(1-ethylpropyl)amino]-3,5-dinitro-o-toluic acid. The guideline requirement (GLN 162-2) is fulfilled. MRID 40185105

Anaerobic Aquatic Metabolism

The calculated half-lives were 6, 30, 33, 45, 52, 59, 62, 63, and 105 days.

A half-life of 105 days was calculated in silt loam soil (1.2% OC) that was incubated for one week under aerobic conditions and for 8 weeks under anaerobic conditions. Only minor degradates (<2.5%) were isolated; none were identified. Less than 3% was associated with the flood water at any time in the study. (GLN 162-3) MRID 40813501, reviewed on 6/27/91.

A half-life of 6 days was calculated for non-sterilized sandy loam pond sediment from Ontario, Canada (1.8% OC) at 25ºC incubated for 39 days under anaerobic aquatic conditions. In all conditions (5ºC non-sterile, 5ºC, sterile, 25ºC, non-sterile, and 25ºC, sterile), aqueous residues decreased rapidly to form soil-extractable residues, followed by a rapid increase in soil-bound residues. At 5ºC and 25ºC under non-sterile conditions, aqueous residues declined to about 11.8% by 16 days and remained constant until the end of the study at 39 days. Extractable residues decreased from 60.8-70.9% at 5ºC (non-sterile) to 27% by 39 days. Many minor (<10%) degradates were isolated, and none were identified. Gln. 162-3, MRID 43154702, reviewed for reregistration.

The calculated half-lives for 30 kPa (100% FC), continuous flood, and alternate wet/dry treatments were 59, 63, and 30 days, respectively, in Crowley silt loam soil (5% sand, 74% silt, 21% clay, pH 5.5, 1% OC). Soil persistence decreased with increasing soil moisture content. Alternating wet/dry conditions decreased persistence presumably by increasing the volatility during the wet cycle. Barrett and Lavy, 1983.

The calculated half-lives were 62, 52, 45, and 33 days in sterile, non-flooded; non-sterile, non-flooded; sterile, flooded; and non-sterile, flooded sandy loam soil with 60% sand, 21% silt, 19% clay, 0.35% OC, and Ph 8.2. Persistence decreased with flooded conditions regardless of sterility. Three minor degradates with ring rearrangements were formed. Kulshrestha and Singh, 1992.

As reported in another study, between 45-59% of pendimethalin was bound to sediment (Matapeake silt loam, pH 5.3, 0.87% OM, 38.4% sand, 49.4% silt, and 12.2% clay) by 30 days. Only 11-13% of residues were associated with the aqueous phase throughout the study. Polar residues reached 54% by 2 days and >90% by 9-30 days. A total of 32% of soil residues was extractable. Isensee and Dubey, 1983.

The guideline requirement (GLN-162-3) is fulfilled. MRIDs 40813501;43154702).

(2) Mobility

Unaged Mobility (Batch Equilibrium)

Parent pendimethalin was essentially immobile in loamy sandy (0.46% OC), sandy loam (0.93% OC), silt loam (2.73% OC), loam (2.21% OC), and silty clay loam (2.91% OC), and sandy clay loam (1.5% OC) soils from the U.S. with Freundlich K_{ads} values of 30, 110, 380, 301, and 854, respectively. Desorption coefficients were not provided. K_{ocads} were 15000, 13000, 14100, 13700, and 29400, respectively. The N values were 1.05, 1.08, 0.89, 1.20, and 0.83, respectively. The guideline requirement (GLN 163-1) is fulfilled. MRID 00153765

Parent pendimethalin was essentially immobile in loamy sandy (0.87% OC), sandy loam (0.44% OC), sandy clay loam (0.67% OC), and sandy clay loam (1.5% OC) soils from Japan with Freundlich K_{ads} values of 61, 193, 153, and 285, respectively. Freundlich K_{des} values were 124, 284, 323, and 556, respectively. K_{ocads} were 7011, 43863, 22835, and 19000 and K_{ocdes} values were 14252, 64545, 48208, and 37066, respectively. The N values ranged from 1.03-1.13. Gln 163-1, MRID 43041901

Aged Mobility

Waived for reregistration since there are no significant transformation products of pendimethalin. Gln. 163-1.

Laboratory Volatility

Volatility can be significant under warm, moist conditions. The maximum volatility rate for air-dried sandy loam soil (0.8% OC) was 5.4×10^{-5} µg/cm^2/hr and the maximum air concentration was 0.54 ug/m^3. The maximum volatility rate for moist (80% FC) sandy loam soil was 2.1×10^{-3} cm^2/hr and the maximum air concentration was 31 ug/m^3. The moist soil volatility rate and air concentration were approximately 38 times and 57 times that of the dry soil (respectively). The guideline requirement (GLN 163-2) is fulfilled. MRID 00153766

Table 5. Volatility Half-lives (Walker and Bond, 1977).

Surface*	Half-life (days)
Bare Metal (aluminum)	6
Dry Sheeps Pen (1.2% OC, 18% clay)	96
Moist Sheeps Pen (1.2% OC, 18% clay)	37

* Incomplete soil characterization information was provided.

Volatilization of pendimethalin may be responsible for some of the accelerated rate of loss as the soil moisture increases.

(3) Accumulation

Bioaccumulation in Fish

Pendimethalin residues accumulated in bluegill sunfish exposed to 3 ppb of pendimethalin, with BCF's of 1400X for edible, 5800X for non-edible, and 5100X for whole fish. Pendimethalin comprised 68-81% of the recovered radioactivity, and the degradate 4-[(1-ethylpropyl-amino]-2-methyl-3,5-dinitro-benzyl alcohol (CL 202,347) was 2-3.1% of the recovered radioactivity. Many other minor degradates were formed up to 32% of the applied radioactivity. Depuration was rapid, with 87-91% of the ^{14}C-residues eliminated from the fish tissues by 14 days of depuration. The guideline requirement (GLN 165-4) is fulfilled. MRIDs 00158235;00156726

(4) Field Dissipation

Terrestrial Field Dissipation

No acceptable field dissipation studies were submitted for the major crops treated with pendimethalin (cotton and soybeans). The registrant should provide studies for these crops, since the orchard study in CA is not necessarily representative of soybeans and cotton. These studies can be modified to include volatility information.

The calculated half-life of pendimethalin in sandy loam soil in an almond orchard in California was 34 days. No leaching was observed below 6 inches of depth. Gln. 164-1, MRID 41722504

Walker and Bond (1977) observed that volatilization occurred more rapidly with warmer soil temperatures in English Sheeps Pen and Big Ground soils. In the field, up to 50% volatilized in 30-40 days from the first surface application, and in 12-14 days from the second surface application. Pendimethalin was lost more rapidly from surface treatments than in incorporated treatments. When incorporated, between 65-80% remained in field soil 20-23 weeks after application. Walker and Bond, 1977.

The guideline requirement (164-1) is not fulfilled. Additional studies are needed.

Aquatic Field Dissipation

Aquatic field dissipation is unsatisfied at this time since no study has been submitted to the agency. However, the registrant has conducted an aquatic field dissipation study in dry-seeded rice in Arkansas that has not yet been submitted. The guideline requirement (GLN-164-2) is not fulfilled.

(5) Spray Drift

Spray Drift

No pendimethalin specific studies were reviewed. Droplet size spectrum (GLN 201-1) and drift field evaluation (GLN 202-1) studies are required for pendimethalin, since the different formulations may be applied by aircraft and it is estimated that there will be detrimental effects to non-target terrestrial and semi-aquatic plants due to drift. However, to satisfy these requirements the registrant, in conjunction with other registrants of other pesticide active ingredients, formed the Spray Drift Task Force (SDTF). The SDTF has completed and submitted to the Agency its series of studies which are intended to characterize spray droplet drift potential due to various factors, including application methods, application equipment, meteorological conditions, crop geometry, and droplet characteristics. During 1996 the Agency plans to evaluate these studies. In the interim, and for this assessment of pendimethalin, the Agency is relying on previously submitted spray drift data and the open literature for off-target drift rates. The estimated drift rates at 100 feet downwind of the treated sites are 1% at the applied spray volume from ground applications and 5% from aerial applications. After review of the new studies the Agency will determine whether a reassessment is warranted of the potential risks of the application of pendimethalin products.

c. Water Resources

(1) Ground Water

EFED concludes that pendimethalin has a low potential to leach to ground water in most soils. Pendimethalin exceeds all of the ground water persistence triggers, however, the high K_d and K_{oc} values demonstrate that pendimethalin will bind strongly to soil organic matter and is not mobile. There is no indication that pendimethalin would exceed any ground water LOC. Residues of pendimethalin have been found in ground water in limited areas in two states. The concentrations were relatively low, ranging from 0.2 to 0.9 ppb (µg/L). However, considering its history of high use over a wide geographic area on several major crops, there are relatively few detections in ground water.

(2) Surface Water

Pendimethalin may contaminate surface water from spray drift associated with aerial and ground spray application, or in runoff from rainfall events and through irrigation waters (chemigation). Transport of pendimethalin during runoff events which occur soon after application could be considerable due to its persistence and extensive use. The intermediate to high soil/water partitioning coefficients for pendimethalin (Freundlich K_{ad}s of 30-854 ml/g; K_{oc}s of 7011-64545) indicate pendimethalin would be transported in runoff adsorbed onto eroding soil or entrained sediment. The anaerobic aquatic metabolism and soil mobility studies both reported partitioning of pendimethalin primarily with the soil or sediment phase, and it is not partitioned into the aqueous phase.

Surface waters may be contaminated through drift from aerial and ground spray applications. Pendimethalin is aerially applied to ≈50% of the treated rice fields, <15% of the treated cotton acres, and <5% for all other treated crops (Registrant use information). Based on the environmental fate assessment, volatilization losses of pendimethalin following aerial applications may also be important. At this time, spray drift information is unavailable; however, the registrant is a participating member of the SDTF and data from the SDTF will be available in 1996.

In receiving surface water bodies, pendimethalin is moderately persistent (anaerobic aquatic metabolism half-life of 60 days). Pendimethalin is stable to hydrolysis; however it degrades by aqueous photolysis (half-lives of 17-21 days) and should dissipate fairly rapidly in shallow water exposed to sunlight. Volatilization of pendimethalin from well-mixed surface waters may be an important transport process because greater volatilization was observed under moist field conditions (maximum of 50% volatilized from moist soils in field studies) than for dry soils. The reported vapor pressure of 2.9×10^{-6} Torr at 20°C and estimated Henry's Law Constant of 2.2×10^{-5} atm-m^3-mol^{-1} support the conclusion of volatility as a significant transport mechanism.

Pendimethalin is not regulated under the Safe Drinking Water Act (SDWA); therefore, a

Maximum Contaminant Level (MCL) has not been established for it. Pendimethalin is classified in Toxicity Category III based on the Oral LD_{50} from a rat study and has been classified as a Group C nonquantifiable carcinogen by the HED Carcinogenicity Peer Review Committee (RCAB risk assessment summary, 1/17/96).

Monitoring Data

Baker (1988) studied sediment, nutrient, and pesticide transport in selected Lower Great Lake Tributaries during 1982-1985. Pendimethalin was detected in surface water samples from numerous river transport stations. Maximum concentrations of pendimethalin were 3.66 µg/L (Upper Honey Creek) for 1983; 1.25 µg/L (Honey Creek) for 1984, and 0.31 µg/L (Lost Creek) for 1985. The maximum concentrations for pendimethalin in stream water samples for selected Lower Great Lakes Tributaries are summarized in Table 6 (Baker, 1988).

Table 6. Maximum Concentrations of Pendimethalin for 1982-1985 (Baker, 1988)

SAMPLING LOCATION	1982	1983 (µg/L)	1984 (µg/L)	1985 (µg/L)
Maumee River	n/a	0.269	0.666	0.0
Sandusky River	n/a	0.371	0.570	0.130
Honey Creek	n/a	0.623	1.248	0.230
Rock Creek	n/a	0.470	0.276	0.0
U. Honey Creek	n/a	3.660	0.055	0.0
Lost Creek	n/a	3.455	0.346	0.310
River Raisin	n/a	0.333	0.080	0.0
Cuyahoga River	n/a	1.057	0.139	0.0

Note: data for 1984 and 1985 were corrected for recoveries less than 100%.

In a study of the spatial and temporal distributions of pesticides and nutrients in the Mississippi River and its tributaries, Coupe et al. (1993) did not detect dissolved pendimethalin in surface water samples above the reporting limit of 0.018 µg/L. These study results suggest pendimethalin would not be present in public drinking water. The sampling period was April, 1991 to September, 1992 for eight sampling stations (three on the Mississippi, and one each on the Ohio, Illinois, Missouri, Platte, and White Rivers). The USGS study focused on selected pesticides associated with agriculture row crop production and employed extensive field and laboratory quality assurance procedures to generate high-quality monitoring data.

A summary of the pendimethalin detections in the STORET database are shown in Table 7. The surface water monitoring results found in the STORET database are a compilation of

various states' monitoring data. The STORET data does not have strict quality assurance criteria. The maximum concentration of pendimethalin was 17.6 µg/L (ppb) for a surface water sample collected in Ohio; the next highest reported concentration was 10 µg/L with a range of 1-10 µg/L. From the STORET data (excluding the highest Ohio sampling results), the maximum concentrations of pendimethalin in surface water samples range from 0.01 to 3.2 µg/L.

Table 7. Summary of Pendimethalin Detections in STORET database

STATE	MONITORING PERIOD	DETECTIONS/ SAMPLES	MAXIMUM CONCENTRATION -- µg/L --
AR	1995	12/35	0.08
CA	1992-94	20/291	0.30
CO	1993-94	32/92	3.2
CT	1993-94	2/2	0.12
KS	1993	1/1	0.01
LA	1995	2/2	0.06
NE	1992-93	17/71	0.07
OH	1981-87	650/2436	17.6
OR	1992-95	8/64	0.25
PA	1993-95	56/207	0.24
TX	1995	1/1	0.04
WA	1993-94	26/81	0.19
WI	1993-94	16/122	0.05

2. Ecological Toxicity

a. Toxicity to Terrestrial Animals

(1) Birds, Acute and Subacute

An oral (LD_{50}) study (preferably mallard duck or bobwhite quail) and two subacute dietary (LC_{50}) studies (one species of waterfowl, preferably the mallard duck and one species of upland game bird, preferably bobwhite quail) are required to establish the acute and subacute toxicity of a pesticide to birds. Results of these tests are tabulated below.

Table 8: Avian Acute Oral Toxicity Findings (LD_{50})

Species	% A.I.	LD_{50} (mg/kg)	Accession No. Author/Year	Toxicity Category	Fulfills Guideline Requirement?
Mallard Duck	Technical	1,421	00059739 Fink/1976	Slightly toxic	Yes

Table 9: Avian Subacute Dietary Toxicity Findings (LC_{50})

Species	% A.I.	LC_{50} (ppm)	Accession No. Author/Year	Toxicity Category	Fulfills Guideline Requirement?
Northern Bobwhite Quail	Technical	4,187	00026675 Fink/1973	Slightly toxic	Yes
Mallard Duck	Technical	4,640	00026674 Fink/1973	Slightly toxic	Yes

These results indicate that pendimethalin is slightly toxic to avian species on an acute oral and subacute dietary basis. The guideline requirements (71-1(a) and 71-2(a) & (b)) are fulfilled (Accession No. 00059739, 00026675, 00026674).

(2) Birds, Chronic

Avian reproduction studies using the technical grade of the active ingredient are required because pendimethalin has been shown to have a half-life of 4 days in both field and laboratory studies. It has a high potential to bioaccumulate in fish. Pendimethalin is a widely used agrochemical with up to 25 million pounds per year applied nationwide and may be applied several times per use season on various crops. Therefore, avian reproduction studies are requested for all use sites. An avian chronic hazard assessment cannot be completed without these studies. The guideline (71-4) is not fulfilled.

(3) Mammals

Data from available mammalian studies which are used for human health risk assessment will be used to estimate toxicity to wild mammalian species. A rat acute oral LD_{50} study (81-1, MRID# 00026657) resulted in an LD_{50} of 1050 mg/kg for female rats and 1250 mg/kg for

male rates. These results indicate that pendimethalin is slightly toxic to small mammals on an acute oral basis.

A two-generation rat reproduction study (83-4, MRID # 41725203) reported a reproductive NOEL of 2500 ppm and an LOEL of 5000 ppm.

(4) Insects

A honey bee acute contact LD_{50} study using the technical grade of the active ingredient is required for pendimethalin because of the extensive agricultural use patterns. The result of this test is provided below.

Table 10: Nontarget Insect Acute Contact Toxicity Findings

Species	% A.I.	LD_{50} (µg/bee)	MRID No. Author/Year	Toxicity Category	Fulfills Guideline Requirement?
Honey Bee	Tech	>49.7	00099890 Atkins/1974	Practically nontoxic	Yes

The results indicate that pendimethalin is practically nontoxic to bees on an acute contact basis. The guideline requirement (141-1) is fulfilled (MRID 00099890).

b. Toxicity to Aquatic Animals

(1) Freshwater Fish, Acute

Two freshwater fish toxicity studies using the technical grade of the active ingredient are required to establish the toxicity of a pesticide to freshwater fish. One study should use a coldwater species (preferably the rainbow trout), and the other should use a warmwater species (preferably the bluegill sunfish). Results of these tests are tabulated below.

Table 11: Freshwater Fish Acute Toxicity Findings for Technical Pendimethalin

Species	% A.I.	LC_{50} (ppm)	Accession No. Author/Year	Toxicity Category	Fulfills Guideline Requirement?
Rainbow trout	93.2	0.138	106764 Sleight/1973	Highly toxic	Yes
Bluegill sunfish	93.2	0.199	106764 Sleight/1973	Highly toxic	Yes
Channel catfish	93.2	0.418	106764 Sleight/1973	Highly toxic	Yes

The results indicate that technical pendimethalin is highly toxic to fish on an acute basis. The guideline requirement (72-1(a) & (c) is fulfilled (Accession No. 106764).

Freshwater fish toxicity studies using a typical end use product were conducted. Results of these tests are tabulated below.

Table 12: Freshwater Fish Acute Toxicity Findings for the Formulated product

Species	% A.I.	LC_{50} (ppm)	Accession No. Author/Year	Toxicity Category	Fulfills Guideline Requirement?
Rainbow trout	45	0.52	00037927 Bentley/1974	Highly toxic	Yes, for formulation
Bluegill sunfish	45	0.92	00037927 Bentley/1974	Highly toxic	Yes, for formulation
Channel catfish	45	1.9	000251601 Sousa/1983	Moderately toxic	Yes, for formulation

The results indicate that this formulated product of pendimethalin is highly to moderately toxic to fish on an acute basis. The guideline requirement (72-1(b) & (d)) is fulfilled (Accession No. 00037927, 000251601).

(2) Freshwater Fish, Chronic

A fish life-cycle test using the technical grade of the active ingredient is required for pendimethalin because it can be aerially applied, it has extensive use sites, many of which may occur near water bodies and has a halflife of greater than 4 days. The preferred test species is the fathead minnow. Results of this test are tabulated below.

Table 13: Fish Life-Cycle Toxicity Findings

Species	% A.I.	NOEC/LOEC (ppb)	MATC (ppb)	Accession No. Author/Year	Endpoints Affected	Fulfills Guideline Requirement?
Fathead minnow	98.3	6.3/9.8	7.85	00096342 EG&G Bionomics/1975	Egg production reduced at 9.8 ppb; reduced hatch at 22 and 43 ppb.	Yes

The results indicate that reproductive effects to freshwater fish may occur at levels greater than 6.3 ppb (µg/L). The guideline requirement (72-5) is fulfilled (Accession No. 00096342).

(3) Freshwater Invertebrates, Acute

A freshwater aquatic invertebrate toxicity test using the technical grade of the active ingredient is required to assess the toxicity of a pesticide to freshwater invertebrates. The preferred test organism is *Daphnia magna*, but early instar amphipods, stoneflies, mayflies,

or midges may also be used. Results of this test are tabulated below.

Table 14: Freshwater Invertebrate Toxicity for Technical Pendimethalin and the Formulated Product

Species	% A.I.	LC_{50}/EC_{50} (ppm)	Accession No. Author/Year	Toxicity Category	Fulfills Guideline Requirement?
Daphnia magna	Technical	0.28	FAOPEN05 EG&G Bionomics/1976	Highly toxic	Yes
Daphnia magna	45.6	5.1	260404 Forbis/1985	Moderately toxic	Yes for formulated product
Procambarus simulans Crayfish	94.2	1.0	00099889 ABC Inc./ 1980	Highly toxic	No - supplemental

The results indicate that technical pendimethalin is highly toxic to aquatic invertebrates on an acute basis and a formulated product of pendimethalin is moderately toxic to aquatic invertebrates on an acute basis. The guideline requirement (72-2(a) & (b)) is fulfilled (Accession No. FAOPEN05 & 260404).

(4) Freshwater Invertebrate, Chronic

Data from an aquatic invertebrate life-cycle test using Daphnia magna are required because pendimethalin is toxic to Daphnia magna (EC_{50} of 0.28 ppm), is registered for uses that involve multiple applications and has a halflife of greater than 4 days. Results of this test are tabulated below.

Table 15: Aquatic Invertebrate Life-Cycle Toxicity Findings

Species	% A.I.	NOEC/LOEC(ppb)	MATC (ppb)	Accession No. Author/Year	Endpoints Affected	Fulfills Guideline Requirement?
Daphnia magna	92.2	14.5/35.8	22.78	247299 Gramey/1981	Mean brood size	Yes

The results indicate that aquatic invertebrate reproductive impairment may occur at levels greater than 14.5 ppb (µg/L). The guideline requirement (72-4(b)) is fulfilled (Accession No. 247299).

(5) Estuarine and Marine Animals, Acute

Acute toxicity testing with estuarine and marine organisms (fish, shrimp and oyster embryo-larvae or shell deposition) using the technical grade of the active ingredient is required for pendimethalin because of the extensive agricultural use patterns near estuarine and marine habitats and labeling permits aerial application. Results of these tests are tabulated below.

Table 16: Estuarine/Marine Acute Toxicity Findings for Technical Pendimethalin

Species	% A.I.	LC_{50}/EC_{50} (ppm)	Acc. No. Author/Year	Toxicity Category	Fulfills Guideline Requirement?
Eastern oyster (embryo-larvae)	92.2	0.210	251601 Ward/1983	Highly toxic	Yes
Sheepshead minnow	92.2	0.707	251601 Ward/1983	Highly toxic	Yes
Pink shrimp	92.2	1.6	251601 Ward/1983	Moderately toxic	Yes

The results indicate that technical pendimethalin is moderately to highly toxic to estuarine/marine organisms on an acute basis. The guideline requirement (Gdln 72-3 (a), (b), & (c)) is fulfilled (Accession No. 251601).

Estuarine/marine toxicity studies using the typical end use product were provided. Results of these tests are tabulated below.

Table 17: Estuarine/Marine Acute Toxicity Findings for Formulated Product
Eastern oyster

Species	% A.I.	LC_{50}/EC_{50} (ppm)	Acc. No. Author/Year	Toxicity Category	Fulfills Guideline Requirement?
Eastern oyster (embryo-larvae)	45	0.450	251601 Ward/1983	Highly toxic	Yes, for formulation
Sheepshead minnow	45	1.7	251601 Ward/1983	Moderately toxic	Yes, for formulation
Pink shrimp	45	11	251601 Ward/1983	Slightly toxic	Yes, for formulation

The results indicate that this formulated product of pendimethalin is slightly to highly toxic to estuarine/marine organisms on an acute basis. The guideline requirement (Gdln 72-3(d), (e), & (f)) is fulfilled (Accession No. 251601).

c. Toxicity to Plants

(1) Terrestrial

Terrestrial plant testing (seedling emergence and vegetative vigor) is required for pendimethalin because it is volatile (vapor pressure $\geq 1.0 \times 10^{-5}$mm Hg at 25°C), it can be aerially applied and because it may affect endangered plant species which are located near the use areas.

For the seedling emergence and vegetative vigor testing the following plant species and groups should be tested: (1) six species of at least four dicotyledonous families, one species of which is soybean (Glycine max), and the second of which is a root crop, and (2) four species of at least two monocotyledonous families, one of which is corn (Zea mays).

Results of Tier II seedling emergence toxicity testing on the technical material are tabulated below.

Table 18: Nontarget Terrestrial Plant Seedling Emergence Toxicity Findings (Tier II)

Most Sensitive Species	% A.I.	Parameter Affected	NOEC (lbs a.i./A)	EC_{25} (lbs a.i./A)	MRID No. Author/Year	Fulfills Guideline Requirement?
Ryegrass	92.98	Percent emergence	0.02	0.03	42372201 Chetram & Gagne/1992	Yes
		Percent survival	0.02	0.06		
		Phytotoxicity rating	0.02	N/A		
		Plant height	0.01	0.05		
		Plant weight	0.01	0.02		

These results indicate that exposure levels of greater than 0.01 lbs a.i./A may cause significant detrimental effects on certain terrestrial plants. The guideline requirement (123-2) is fulfilled (MRID 42372201).

Results of Tier II seedling germination toxicity testing on the technical material are tabulated below.

Table 19: Nontarget Terrestrial Plant Seedling Germination Toxicity Findings (Tier II)

Most Sensitive Species	% A.I.	NOEC (lbs a.i./A)	EC_{25} (lbs a.i./A)	MRID No. Author/Year	Fulfills Guideline Requirement?
Ryegrass	92.98	0.25	0.82	42372202 White & Gagne/1992	Yes

These results indicate that exposure levels of greater than 0.25 lbs a.i./A may cause significant detrimental effects on the germination of certain terrestrial plants. The guideline requirement (123-2) is fulfilled (MRID 42372202).

Results of Tier II vegetative vigor toxicity testing on the technical material are tabulated below.

Table 20: Nontarget Terrestrial Plant Vegetative Vigor Toxicity Findings (Tier II)

Most Sensitive Species	% A.I.	Parameter Affected	NOEC (lbs a.i./A)	EC_{25} (lbs a.i./A)	MRID No. Author/Year	Fulfills Guideline Requirement?
Ryegrass and lettuce	92.98	Phytotoxicity rating	0.063	N/A	42372203 Canez & Gagne/1992	Yes - classified as supplemental but fulfills guideline requirement
Onion		Percent survival	1.0	1.4		
Ryegrass		Plant height	0.063	0.10		
Ryegrass		Plant dry weight	<.035	0.035		

These results indicate that exposure levels of greater than 0.063 lbs a.i./A may cause significant detrimental effects on the vigor of certain terrestrial plants. The guideline requirement (123-2) is fulfilled (MRID 42372203).

(2) Aquatic

Aquatic plant testing is required for pendimethalin. Results of Tier II toxicity testing on the technical material are tabulated below.

Table 21: Nontarget Aquatic Plant Toxicity Findings (Tier II)

Species	% A.I.	EC_{50} (ppb)	NOEC (ppb)	MRID No. Author/Year	Fulfills Guideline Requirement?
Freshwater diatom *Navicula pelliculosa*	92.98	5.8	3.2	42372206 Hughes et al/1992	Yes
Duckweed *Lemna gibba*	92.98	12.5	5.6	42137101 Hughes et al/1991	Yes
Green algae *Selenastrum capricornutum*	92.98	5.4	3.0	42372204 Hughes et al/1992	Yes
Marine diatom *Skeletonema costatum*	92.98	5.2	0.7	42372205 Hughes et al/1992	Yes
Blue-green algae *Anabaena flos-aquae*	92.98	> 174	98	42372207 Hughes et al/1992	Yes

These results indicate that exposure levels of greater than 0.7 ppb (µg/L) of pendimethalin

may cause detrimental effects to the growth and reproduction of certain aquatic plant species. The guideline requirement (123-2) is fulfilled (MRID 42372206, 42137101, 42372204, 42372205, 42372207).

3. Exposure and Risk Assessment

a. Ecological Exposure and Risk Assessment

Explanation of the Risk Quotient (RQ) and the Level of Concern (LOC): The Levels of Concern are criteria used to indicate potential risk to nontarget organisms. The criteria indicate that a chemical, when used as directed, has the potential to cause undesirable effects on nontarget organisms. There are two general categories of LOC (acute and chronic) for each of the four nontarget faunal groups and one category (acute) for each of two nontarget floral groups. In order to determine if an LOC has been exceeded, a risk quotient must be derived and compared to the LOC's. A risk quotient is calculated by dividing an appropriate exposure estimate, e.g. the estimated environmental concentration (EEC), by an appropriate toxicity test effect level, e.g. the LC_{50}. The acute effect levels typically are:

-EC_{25} (terrestrial plants),
-EC_{50} (aquatic plants and invertebrates),
-LC_{50} (fish and birds), and
-LD_{50} (birds and mammals)

The chronic test results are the:

-NOEL (sometimes referred to as the NOEC) for avian and mammal reproduction studies, and either the NOEL for chronic aquatic studies, or the Maximum Allowable Toxicant Concentration (MATC) which is the geometric mean of the NOEL and the LOEL (sometimes referred to as the LOEC) for chronic aquatic studies.

When the risk quotient exceeds the LOC for a particular category, risk to that particular category is presumed to exist. Risk presumptions are presented along with the corresponding LOC's.

Levels of Concern (LOC) and associated Risk Presumption

Mammals, Birds

IF THE	LOC	PRESUMPTION
acute RQ>	0.5	Potentially high acute risk
acute RQ>	0.2	Risk that may be mitigated through restricted use
acute RQ>	0.1	Endangered species may be affected acutely
chronic RQ>	1	Chronic risk, endangered species may be affected chronically,

Fish, Aquatic invertebrates

IF THE	LOC	PRESUMPTION
acute RQ>	0.5	Potentially high acute risk
acute RQ>	0.1	Risk that may be mitigated through restricted use
acute RQ>	0.05	Endangered species may be affected acutely
chronic RQ>	1	Chronic risk, endangered species may be affected chronically

Plants

IF THE	LOC	PRESUMPTION
RQ>	1	Potentially high risk
RQ (using the NOEC or EC05) >	1	Endangered plants may be affected

Currently, there are no separate criteria for restricted use or chronic effects for plants.

Pendimethalin use patterns addressed in risk assessment: Pendimethalin is used on a wide variety of agricultural crops as well as many non-agricultural use sites. The following application rates and use patterns were assessed. These were based on labels and registrant information:

Terrestrial Animals and Terrestrial and Semi-aquatic Plants: The majority of use sites have a maximum use rate of 2.0 lbs ai/A or less. This includes such sites as corn, cotton, beans, grain sorghum, peanuts (1 lb ai/A), soybeans, rice (1 lb ai/A) and some others. These use sites make up over 90% of pendimethalin usage based on pounds applied annually. Risk based on this rate is considered to be typical for pendimethalin. However, there are some use sites that have higher single application rates and higher maximum seasonal rates. Although these make up less than 10% of pendimethalin usage, they still represent several million pounds of ai applied annually. These include:

Turf (max. single = 3 lb ai/A, max. seasonal = 5 lbs ai/A),
Onions (max. single = 2 lbs ai/A, max. seasonal = 6 lbs ai/A),
Sugarcane (max. single = 4 lbs ai/A, max. seasonal = 6 lbs ai/A) and
Ornamentals, landscape sites, non-cropland and alfalfa grown for seed (max. single = 4 lbs ai/A, max. seasonal = 4 lbs ai/A).

Aquatic Animals and Plants: Aquatic EECs were calculated using GENEEC for the following use rates and patterns

1) 1.0 lb ai/A - typical application rate applied once on a variety of agricultural crops including cotton, corn, and soybeans, both ground and aerial,

2) 2.0 lbs ai/A - maximum single application rate for cotton, soybeans, corn and other use patterns having a maximum application rate of 2 lbs ai/A, both ground and aerial,

3) 1.0 lbs ai/A - typical application rate for cotton, applied twice, with a two week application interval, both ground and aerial application,

4) 4 lbs ai/A for alfalfa grown for seed and sugarcane, applied once per season, both ground and aerial application, and

5) 2 lbs ai/A for onions applied 3 times per season at two week intervals, both ground and aerial application.

Aquatic EEC's were not estimated for rice (1.0 lb ai/A), turf, ornamental, landscape & grounds maintenance, non-cropland, and nonbearing nuts and vines (use rates of 3 and 4 lbs ai/A, ground application only). GENEEC is a model designed specifically to model runoff from certain agricultural fields and the risk assessment team did not consider it appropriate for sites such as these. It is assumed, for assessment purposes, that exposure from these use patterns would not be higher than exposure from other uses where GENEEC was used to estimate exposure. Exposure from the rice use is not expected to be greater than from the cotton use at 1.0 lb ai/A. Rationale for this is provided in Section 4 Environmental Risk Characterization.

(1) Exposure and Risk to Nontarget Terrestrial Animals

(a) Birds

Residues found on dietary food items following application are compared to LC_{50} values to predict hazard to birds. Day 0 residues on vegetation were estimated based on the work of Hoerger and Kenaga (1972) as modified by Fletcher et al. (1994) for application rates of 4.0 lbs, 3.0 lbs and 2.0 lbs ai/A. For cotton (1.0 lb ai/A), the highest (peak) residues after the second application were estimated using a computerized dissipation program that calculates daily estimated residues after repeated applications and first-order dissipation kinetics at an

assumed rate. The use rate per application is 1.0 lb ai/A with an between application interval of two weeks (14 days), during which time the residues from the first application would partially degrade. The aqueous photolysis half-life of 21 days was used to estimate the degradation of pendimethalin on vegetation.

The predicted 0 day maximum of pendimethalin that may be expected to occur on different avian food items following various applications of pendimethalin, and their corresponding risk quotients, are presented in the table below:

Table 22: Estimated Environmental Concentrations and Dietary Risk Quotients for Birds (Based on an LC_{50} = 4,187 ppm)

Food items	EEC - ppm 4.0 lbs ai/A	RQ Acute	EEC - ppm 3.0 lbs ai/A	RQ Acute	EEC - ppm 2.0 lbs ai/A	RQ Acute	EEC - ppm 1.0 lbs a.i./A	RQ Acute
Short Grasses	960	**0.2**	720	**0.2**	480	0.1	391	<0.1
Long Grasses	440	0.1	330	0.08	220	<0.1	180	<0.1
Broadleaf Plants and insects	540	0.1	405	0.1	270	<0.1	220	<0.1
Fruits and pods	60	<0.1	45	<0.1	30	<0.1	24	<0.1

Pendimethalin has low acute toxicity to birds, therefore, the risk quotients are small. The LOC for endangered species (0.1) has been slightly exceeded for the turf use (3.0 application rate) and smaller acreage use sites (4.0 lbs ai/A). Therefore, a may effect for endangered species, specifically grazers, has been identified. The risk quotients at 3.0 and 4.0 lbs ai/A are approximate to the restricted use LOC (0.2). However, the use of pendimethalin is expected to pose minimal overall acute risk to avian species, as further described in Section 4 Environmental Risk Characterization.

Chronic risk to avian species cannot be determined at this time due to lack of data.

(b) Mammals

Mammals are assumed to be exposed to dietary residues similar to birds. The EEC's calculated in Table 22 will be used to estimate exposure to mammals.

Small mammal acute risk is usually addressed using acute oral LD_{50} values converted to estimate an LC_{50} value for comparison with dietary exposure. However, in the case of pendimethalin, it was determined that the 2-generation reproductive toxicity study with rats which reported no mortality at 2500 ppm (NOEL for acute and subacute effects) was a better indicator of potential for acute toxicity from dietary exposure. The maximum estimated concentration on mammalian food items is 960 ppm. Because the maximum EEC is much less than the NOEL, where no effects, either sublethal or lethal, occurred, it is unlikely that

mammals, including endangered mammal species, would be exposed to enough pendimethalin to cause adverse effects.

Based on the same 2-generation reproductive toxicity study in rats minimal chronic risk to mammalian species, including endangered species, is expected. The NOEL of 2500 ppm is much higher than the maximum EEC of 960 ppm.

(c) Insects

Pendimethalin is practically non-toxic to honeybees. Honeybees are not likely to be adversely affected by the use of pendimethalin.

(2) Exposure and Risk to Nontarget Aquatic Animals

Expected Aquatic Concentrations: EFED calculated Generic Estimated Environmental Concentrations (GEECs) for pendimethalin application to a variety of crops at several different rates and application patterns. These GEECs are designed as a coarse screen and depends on basic chemical parameters and pesticide label application information. The GENeric Expected Environmental Concentration Program (GENEEC) which was used to calculate the GEECs is a Tier I model which uses a chemical's soil/water partition coefficient and degradation half-life values to estimate runoff from a ten hectare field into a one hectare by two meter deep pond. GENEEC was designed to specifically model runoff from agricultural fields.

GENEEC calculates both acute and chronic generic EEC values. It considers reduction in dissolved pesticide concentration due to adsorption of pesticide to soil or sediment, incorporation, degradation in soil before washoff to a water body, direct deposition of spray drift into the water body, and degradation of the pesticide within the water body. Review of the Spray Drift Task Force data has not been completed, so spray drift is assumed to be 1% of the application rate for ground applications and 5% of the application rate for aerial applications.

The following values were used for input into the GENEEC program:

Soil organic carbon partitioning coefficient:	7011
Soil aerobic metabolic half-life	172 days
Hydrolysis half-life:	Stable
Photolysis half-life:	Stable
Aquatic aerobic metabolic half-life	Stable

Water solubility: 375 ppb

Table 23: Generic EECs for Pendimethalin

Crop	Application Method	Application Rate in lbs a.i./A (number of apps.)	Peak EEC (ppb)	4-day EEC (ppb)	21-day EEC (ppb)	56-day EEC (ppb)
Soybeans, Cotton, Corn	Broadcast - ground	1.0 (1) typical rate	3	3	2	1
Soybeans, Cotton, Corn	Aerial	1.0 (1) typical rate	5	4	2	1
Soybeans, Cotton, Corn	Broadcast - ground	2.0 (1) maximum rate	7	6	3	2
Soybeans, Cotton, Corn	Aerial	2.0 (1) maximum rate	10	8	4	3
Cotton	Broadcast - ground	1.0 (2) typical rate - 2 week application interval	7	6	3	2
Cotton	Aerial	1.0 (2) typical rate - 2 week application interval	10	9	5	3
Sugarcane, Alfalfa (grown for seed)	Broadcast- ground	4.0 (1) maximum rate	13	12	6	4
Sugarcane, Alfalfa (grown for seed)	Aerial	4.0 (1) maximum rate	19	17	9	5
Onions	Broadcast - ground	2.0 (3) maximum rate - 2 week application interval	20	17	9	6
Onions	Aerial	2.0 (3) maximum rate - 2 week application interval	31	27	14	9

Peak exposure levels range from 3 to 31 ppb (µg/L), with 56-day average values ranging from 1 to 9 ppb (µg/L).

Since one application at 2.0 lbs ai/A yielded essentially the same GEEC as that from two applications at 1.0 lb ai/A, both of these scenarios will be combined in the risk quotient tables.

(a) Freshwater Fish

Table 24: Acute Risk Quotients (RQ) for Freshwater Fish based on Testing with Technical Pendimethalin

Crop and application method	Application Rate in lbs a.i./A (number of apps.)	Peak EEC (ppb)	Species	96 hour LC_{50} (ppb)	Acute RQ
Soybeans, Cotton and Corn - ground	1.0 (1) - typical	3	Rainbow trout	138	0.02
Soybeans, Cotton and Corn - aerial	1.0 (1) - typical	5			0.04
Soybeans, Cotton and Corn - ground	2.0 (1) - maximum rate	7			0.05
Soybeans, Cotton and Corn - aerial	2.0 (1) - maximum rate	10			**0.07**
Sugarcane, Alfalfa - ground	4.0 (1) - maximum rate	13			**0.09**
Sugarcane, Alfalfa - aerial	4.0 (1) - maximum rate	19			**0.14**
Onions - ground	2.0 (3) - maximum rate 14 day appl. interval	20			**0.14**
Onions - aerial	2.0 (3) - maximum rate 14 day appl. interval	31			**0.22**

Acute

The majority of pendimethalin use is represented by the 1.0 and 2.0 lb ai/A application rates. At the typical rate of 1.0 lb ai/A, no LOCs are exceeded. This suggests fish are not typically at acute risk from pendimethalin.

When using maximum application rates, all use patterns except 2.0 lbs ai/A, ground application, result in acute risk quotients for fish that exceed the endangered species LOC (0.05). Thus pendimethalin may affect endangered fish species under there conditions.

Use patterns involving higher application rates such as sugarcane and alfalfa and onions result in acute risk quotients for fish that exceed the restricted use LOC (0.1) by a small margin.

The EFED assumes that aquatic risk from turf (1.5 to 3.0 lbs ai/A, label indicates ground application only) and landscaping, ornamentals and non-cropland (2.0 to 4.0 lbs ai/A, label indicates ground application only) is not higher that risk from other "ground application" use patterns with similar application rates. Therefore, it is assumed turf, landscaping, ornamentals and noncropland could effect endangered fish species but would not exceed the restricted use LOC.

Aquatic EEC's were not estimated for rice since GENEEC was not designed to estimate aquatic exposure from this use pattern. Aquatic risk from rice (1.0 lb ai/A) is expected to be

less than from the cotton use at 1.0 lb ai/acre as discussed in the Environmental Risk Characterization Section.

None of the use patterns for pendimethalin result in acute risk quotients for fish that exceed 0.5. Thus, high acute risk to fish is unlikely.

Chronic

Based on the MATC from the fathead minnow full life-cycle study (7.85 ppb (µg/L)) and the 56-day average GEECs, most use sites represent minimal chronic risk to fish.

The 56-day average GEEC for *Onions* (4.0 lbs ai/acre, aerial), 9 ppb (µg/L), exceeds the MATC by a small margin indicating potential for chronic risk to fish.

Turf, landscape, ornamental, non-cropland and rice uses are expected to result in minimal chronic risk to fish.

(b) Freshwater Invertebrates

Table 25: Acute Risk Quotients (RQ) for Freshwater Aquatic Invertebrates based on Testing with Technical Pendimethalin

Crop and application method	Application Rate in lbs a.i./A (number of apps.)	Peak EEC (ppb)	Species	96 hour LC_{50} (ppb)	Acute RQ
Soybeans, Cotton and Corn - ground	1.0 (1) - typical rate	3	*Daphnia magna*	280	0.01
Soybeans, Cotton and Corn - aerial	1.0 (1) - typical rate	5			0.02
Soybeans, Cotton and Corn - ground	2.0 (1) - maximum rate	7			0.02
Soybeans, Cotton and Corn - aerial	2.0 (1) - maximum rate	10			0.04
Sugarcane, Alfalfa - ground	4.0 (1) - maximum rate	13			0.05
Sugarcane, Alfalfa - aerial	4.0 (1) - maximum rate	19			**0.07**
Onions - ground	2.0 (3) - maximum rate 14 day appl. interval	20			**0.07**
Onions - aerial	2.0 (3) - maximum rate 14 day appl. interval	31			**0.11**

Acute

Use patterns such as cotton, corn and soybeans involving an application rate of 1.0 to 2.0 lbs ai/A (aerial or ground) do not result in acute risk quotients for aquatic invertebrates that exceed any LOCs. These use patterns represent minimal acute risk to aquatic invertebrates.

Sugarcane and alfalfa, when treated by aerial equipment at 4 lbs ai/A and onions when treated three times at 2.0 lbs ai/A result in acute risk quotients for aquatic invertebrates that exceed the endangered species LOC (0.05) by a small margin.

Aerial application to onions (three times at 2.0 lbs ai/A) results in acute risk that exceeds the restricted use LOC (0.1) by a small margin.

The EFED assumes that aquatic risk from turf (1.5 to 3.0 lbs ai/A, label indicates ground application only) and ornamentals and non-cropland (2.0 to 4.0 lbs ai/A, label indicates ground application only) is not greater than risk from other use patterns with similar application rates. Therefore, it is assumed these use patterns may effect endangered aquatic invertebrates but would not be expected to exceed the restricted use LOC.

Aquatic EEC's were not estimated for rice since GENEEC was not designed to estimate aquatic exposure from this use pattern. Aquatic risk from rice (1.0 lb ai/A) is expected to be less than from the cotton use at 1.0 lb ai/A as discussed in the Environmental Risk Characterization Section. The rice use does not exceed the aquatic invertebrate endangered species LOC.

None of the use patterns for pendimethalin result in acute risk quotients that exceed 0.5. Thus high acute risk to aquatic invertebrates is unlikely.

Chronic

Based on the aquatic invertebrate MATC from the *Daphnia magna* life-cycle study (23 ppb (µg/L)) and 21-day average Generic EECs, the use of pendimethalin represents minimal chronic risk to aquatic invertebrates.

Turf, landscape, ornamental, non-cropland, and rice uses are expected to result in minimal chronic risk to aquatic invertebrates.

(c) Estuarine and Marine Animals

Table 26: Acute Risk Quotients (RQ) for Eastern Oyster based on Testing with Technical Pendimethalin

Crop and application method	Application Rate in lbs a.i./A (number of apps.)	Peak EEC (ppb)	Species	48-hour EC_{50} (ppb)	Acute RQ
Soybeans, Cotton and Corn - ground	1.0 (1) - typical rate	3	Eastern oyster	210	0.01
Soybeans, Cotton and Corn - aerial	1.0 (1) - typical rate	4			0.02
Soybeans, Cotton and Corn - ground	2.0 (1) - maximum rate	7			0.03
Soybeans, Cotton and Corn - aerial	2.0 (1) - maximum rate	10			0.05
Sugarcane, Alfalfa - ground	4.0 (1) - maximum rate	13			**0.06**
Sugarcane, Alfalfa - aerial	4.0 (1) - maximum rate	19			**0.09**
Onions - ground	2.0 (3) - maximum rate 14 day appl. interval	20			**0.09**
Onions - aerial	2.0 (3) - maximum rate 14 day appl. interval	31			**0.14**

Acute

Risk quotients shown are only for the eastern oyster, which had the lowest EC50 of the three estuarine species tested. Risk quotients using the acute toxicity for shrimp and fish would not have exceeded any LOCs. Minimal acute risk to **shrimp** and **estuarine fish** is expected from all pendimethalin uses.

Use patterns such as cotton, corn and soybeans involving an application rate of 1.0 to 2.0 lbs ai/A (aerial or ground) do not result in risk quotients for oysters that exceeds any LOCs. These use patterns represent minimal acute risk to estuarine species.

Sugarcane and alfalfa, when treated by air at 4 lbs ai/A and onions when treated three times at 2.0 lbs ai/A result in acute risk quotients for oysters that exceed the endangered species LOC (0.05) by a small margin.

Aerial application to onions (three times at 2.0 lbs ai/A) results in acute risk quotients that exceed the restricted use LOC (0.1) by a small margin.

The EFED assumes that aquatic risk from turf (1.5 to 3.0 lbs ai/A, label indicates ground application only) and ornamentals and non-cropland (2.0 to 4.0 lbs ai/A, label indicates ground application only) is not greater than risk from other use patterns with similar application rates. Therefore, these use patterns may effect endangered mollusk species but

would not be expected to exceed the restricted use LOC.

Aquatic EEC's were not estimated for rice since GENEEC was not designed to estimate aquatic exposure from this use pattern. Aquatic risk from rice (1.0 lb ai/A) is expected to be less than from the cotton use at 1.0 lb ai/A as discussed in the Environmental Risk Characterization Section.

None of the use patterns for pendimethalin result in acute risk quotients that exceed 0.5. Thus high acute risk to estuarine fish or invertebrates is unlikely.

Chronic

No chronic data with estuarine species were reviewed.

(3) Exposure and Risk to Nontarget Plants

(a) Terrestrial and Semi-Aquatic

EFED does separate risk assessments for nontarget terrestrial and semi-aquatic plants. Nontarget terrestrial plants inhabit non-aquatic areas which are generally well drained. Nontarget semi-aquatic plants inhabit low-lying areas that are usually wet, although they may be dry during certain times of the year. Semi-aquatic plants are not obligatory aquatic plants in that they do not live in a continuously aquatic environment. Both the terrestrial and semi-aquatic plants are exposed to pesticides from runoff and drift. They differ, however, in that terrestrial plants are assumed to be exposed via sheet runoff, whereas semi-aquatic plants are assumed to be exposed via channelized runoff. Calculating runoff exposure is done using a simple model which assumes that a certain percent of that which is applied transports with run off. The percent is based on solubility. Since the solubility is 0.375 ppm, it is assumed no more than 1% of the applied pendimethalin would runoff. Drift from aerial applications is assumed to be 5%, while drift from ground applications would not be expected to exceed 1% of the applied.

Volatilization is also a potential route of exposure, however ecological risk assessment techniques are not currently available to determine risk from such exposure.

Nonendangered Terrestrial and Semi-aquatic Plants

Risk quotients for terrestrial and semi-aquatic plants are derived by dividing an exposure estimate, in lb ai/A, by an EC_{25}, also expressed in lb ai/A. The total loading rate (runoff plus spray drift) is used with the EC_{25} of the most sensitive species in the seedling emergence study to determine the risk quotient for exposure to emerging seedlings. The loading from spray drift alone is used with the EC_{25} value of the most sensitive species in the vegetative vigor study to determine the risk to adult plants from foliar exposure.

The following table outlines the acute risk quotients to terrestrial and semi-aquatic plants using results from toxicity testing with technical pendimethalin.

Table 27: Exposure and Risk Quotients for Terrestrial and Semi-aquatic Plants

Application scenario & rate	Plant type	Exposure scenario	Exposure (lb ai/A)	EC_{25} (lb ai/A)	Risk Quotient
Ground, 2.0 lb ai/A (corn, soybeans and cotton, onions*)	Terrestrial	Sheet runoff + spray drift (1%)	0.04	0.02 (seedling emergence)	2
	Semi-aquatic	Channelized runoff + spray drift (1 %)	0.22	0.02 (seedling emergence)	11
	Terrestrial & semi-aquatic	Spray drift (1%)	0.02	0.035 (veg. vigor)	<1
Aerial, 2.0 lb ai/A (corn, soybeans and cotton, onions*)	Terrestrial	Sheet runoff + spray drift (5%)	0.12	0.02 (seedling emergence)	6
	Semi-aquatic	Channelized runoff + spray drift (5 %)	0.30	0.02 (seedling emergence)	15
	Terrestrial & semi-aquatic	Spray drift (5%)	0.10	0.035 (veg. vigor)	2.8
Ground, 3 lb ai/A (turf)	Terrestrial	Sheet runoff + spray drift (1%)	0.06	0.02 (seedling emergence)	3
	Semi-aquatic	Channelized runoff + spray drift (1 %)	0.33	0.02 (seedling emergence)	16.5
	Terrestrial & semi-aquatic	Spray drift (1%)	0.03	0.035 (veg. vigor)	<1
Ground, 4 lb ai/A (Ornamentals, landscape sites, non-cropland, nonbearing nuts and vines, alfalfa grown for seed, sugarcane)	Terrestrial	Sheet runoff + spray drift (1%)	0.08	0.02 (seedling emergence)	4
	Semi-aquatic	Channelized runoff + spray drift (1 %)	0.44	0.02 (seedling emergence)	22
	Terrestrial & semi-aquatic	Spray drift (1%)	0.04	0.035 (veg. vigor)	1
Aerial, 4 lb ai/A (alfalfa grown for seed, sugarcane)	Terrestrial	Sheet runoff + spray drift (5%)	0.24	0.02 (seedling emergence)	12
	Semi-aquatic	Channelized runoff + spray drift (5 %)	0.60	0.02 (seedling emergence)	30
	Terrestrial & semi-aquatic	Spray drift (5%)	0.20	0.035 (veg. vigor)	6

*Cotton and onion use involves multiple applications, however, the model used to estimate exposure does not handle multiple applications well. It is expected that the risk numbers could be higher with more applications at 2 lbs ai/A.

The LOC (1) for risk to terrestrial and semi-aquatic plant species has been exceeded for both ground and aerial application. This indicates that pendimethalin poses a risk to the vegetative vigor and emergence of nontarget terrestrial and semi-aquatic plants.

Endangered Terrestrial and Semi-aquatic Plants

Risk quotients for endangered terrestrial and semi-aquatic plants are derived by dividing an exposure estimate, in lb ai/A, by an NOEC, also expressed in lb ai/A. The lowest NOEC for terrestrial plants is 0.01 lb ai/A (ryegrass, seedling emergence). The risk quotients for endangered plants based on this NOEC compared to the range of exposures predicted would be from 4 to 60. This indicates that pendimethalin may affect threatened and endangered terrestrial and semi-aquatic plants.

b. Aquatic Plants

The same aquatic exposure values used to estimate risk to fish and invertebrates will be used to estimate risk to aquatic plants.

Nonendangered Aquatic Plants

Risk quotients for nonendangered plants are calculated for aquatic plants by dividing the GEEC by the aquatic plant EC_{50} values. A risk quotient for aquatic vascular plants is based on the EC_{50} of 12.5 ppb (µg/L) for duckweed (*Lemna gibba*). A risk quotient for nonvascular aquatic plants is based on the most sensitive algal or diatom species tested. For pendimethalin, the most sensitive nonvascular plant tested was the marine diatom *Skeletonema costatum* with an EC50 of 5.2 ppb (µg/L).

The following table outlines the risk quotients for nonendangered aquatic plants using results from toxicity testing with technical pendimethalin.

Table 28: Risk Quotients (RQ) for Vascular Aquatic Plants

Crop and application method	Application Rate in lbs a.i./A (number of apps.)	Peak EEC (ppb)	Species	EC_{50} (ppb) [NOEC]	RQs [End Spec]
Soybeans, Cotton and Corn - ground	1.0 (1) - typical rate	3	*Lemna gibba*	12.5 [5.6]	0.2 [0.5]
Soybeans, Cotton and Corn - aerial	1.0 (1) - typical rate	5			0.4 [0.9]
Soybeans, Cotton and Corn - ground	2.0 (1) - maximum rate	7			0.6 **[1.2]**
Soybeans, Cotton and Corn - aerial	2.0 (1) - maximum rate	10			0.8 **[1.8]**
Sugarcane, Alfalfa - ground	4.0 (1) - maximum rate	13			1.0 **[2.3]**
Sugarcane, Alfalfa - aerial	4.0 (1) - maximum rate	19			**1.5 [3.4]**
Onions - ground	2.0 (3) - maximum rate 14 day appl. interval	20			**1.5 [3.6]**
Onions - aerial	2.0 (3) - maximum rate 14 day appl. interval	31			**2.5 [5.5]**

Table 29: Risk Quotients (RQ) for non-vascular plants (representing algae and diatoms)

Crop and application method	Application Rate in lbs a.i./A (number of apps.)	Peak EEC (ppb)	Species	EC_{50} (ppb) [NOEC]	RQs [End Spec]
Soybeans, Cotton and Corn - ground	1.0 (1) - typical rate	3	*Skele-tonema costatum*	5.2 [0.7]	0.6 **[4.3]**
Soybeans, Cotton and Corn - aerial	1.0 (1) - typical rate	5			0.1 **[7.1]**
Soybeans, Cotton and Corn - ground	2.0 (1) - maximum rate	7			**1.3 [10.0]**
Soybeans, Cotton and Corn - aerial	2.0 (1) - maximum rate	10			**2.0 [14.3]**
Sugarcane, Alfalfa - ground	4.0 (1) - maximum rate	13			**2.5 [18.6]**
Sugarcane, Alfalfa - aerial	4.0 (1) - maximum rate	19			**3.6 [27.1]**
Onions - ground	2.0 (3) - maximum rate 14 day appl. interval	20			**3.8 [28.6]**
Onions - aerial	2.0 (3) - maximum rate 14 day appl. interval	31			**6.0 [44.3]**

Typical application rates for many of the large acreage crops for which pendimethalin is registered do not represent a risk to aquatic plants. However, uses of pendimethalin at maximum rates are expected to result in risk to aquatic plants for all sites.

Endangered Aquatic Plants

Risk quotients for endangered aquatic plants are calculated dividing the GEEC by the aquatic plant NOEC or EC05 values. Risk quotients for endangered aquatic vascular plants are based on the NOEC of 5.6 ppb (µg/L) for duckweed (*Lemna gibba*) and the NOEC of 0.7 for *Skeletonema costatum*. The risk quotients for endangered aquatic plants range from less than 1 (*L. gibba*, soybeans, cotton and corn, 1.0 lbs ai/A, ground) to a high of 44 (*S. costatum*, onions, three applications of 2 lbs ai/A, aerial). All uses of pendimethalin may affect endangered aquatic plants.

(4) Endangered Species

The use of pendimethalin may adversely effect endangered species of terrestrial and semi-aquatic plants, aquatic plants and invertebrates including mollusks, fish, and birds (specifically grazers).

When the Endangered Species Protection Program becomes final, limitations in the use of pendimethalin may be required to protect endangered and threatened species, but these limitations have not been defined and may be formulation specific. EPA anticipates that a consultation with the Fish and Wildlife Service may be conducted in accordance with the species-based priority approach described in the Program. After completion of consultation, registrants will be informed if any required label modifications are necessary. Such modifications would most likely consist of the generic label statement referring pesticide users to use limitations contained in county Bulletins.

4. Environmental Risk Characterization

Introduction:

Pendimethalin is a dinitroaniline herbicide registered for use on annual grasses and broadleaf weeds in terrestrial food crop and terrestrial non-food crop use groups. It is a cell growth inhibitor that prevents seedling development and is herbicidally active on the roots and coleoptiles of susceptible weeds. Pendimethalin does not control weeds postemergence and must be soil applied. Formulations include a 3.3 emulsifiable concentrate, a 4.0 emulsifiable concentrate, a 60DG water dispersible granule, and a fertilizer formulation. Application rates range from 1.0 to 4.0 lbs ai/A. Total pendimethalin use ranges from 14 to 25 million pounds active ingredient annually, with the largest usage occurring on soybeans, cotton, and corn.

Summary of Conclusions:

- Pendimethalin dissipates in the environment by binding to soil, microbially-mediated metabolism and volatilization. It is essentially immobile in soil. Although pendimethalin has been detected in ground water (at very low levels), the potential for ground water contamination from pendimethalin residues is low.

- Based on laboratory studies and limited field study information, pendimethalin is slightly to moderately persistent in aerobic soil environments. Persistence decreases with increased temperature, increased moisture and decreased soil organic carbon.

- Pendimethalin may contaminate surface water from spray drift associated with aerial and ground spray application, or in runoff from rainfall events and through irrigation waters (chemigation). However, the high affinity for pendimethalin to bind to soil and sediment particles should limit concentrations of pendimethalin in surface waters.

- Additional terrestrial field dissipation studies for major pendimethalin uses (cotton and soybeans) are requested to fully characterize the fate of pendimethalin.

- Pendimethalin would not represent a high acute risk to birds or a high acute or chronic risk to mammals. The chronic risk to birds could not be determined because avian reproduction studies have not been submitted. These studies are requested.

- Chronic risk LOCs for fish were exceeded by a small margin. But it is presumed that overall, pendimethalin does not represent a high risk to aquatic animals and plants, including estuarine organisms.

- The use of pendimethalin may adversely effect endangered species of terrestrial and semi-aquatic plants, aquatic plants and invertebrates including mollusks, fish, and birds (specifically grazers).

- The risk to nontarget terrestrial and semi-aquatic plants is expected to be moderate. However any impact to floral communities, should it occur, could be extensive because of the high poundage used.

- After evaluating all the data, EFED believes that pendimethalin poses the greatest risk to endangered nontarget organisms and terrestrial and semi-aquatic plants as discussed above, however, this risk is expected to be less than the risk from other herbicides.

Environmental Fate and Water Resources:

Pendimethalin dissipates in the environment by binding to soil, microbially-mediated metabolism, and volatilization. Persistence decreases with increased temperature, increased moisture and decreased soil organic carbon. Pendimethalin forms many minor (<10% of applied) degradates. Residues are tightly bound to soil particles and in aquatic environments, pendimethalin and its degradates are primarily associated with the sediment

and not the aqueous phase. Pendimethalin accumulates readily in bluegill sunfish, however, depuration is also rapid. Field dissipation studies on the major use sites (cotton and soybeans) that would more clearly describe the environmental fate of pendimethalin in the field have not been submitted and are requested. The purpose of these studies is to determine the dissipation routes of pendimethalin and the potential for off site effects from its use.

Pendimethalin may contaminate surface water from spray drift associated with aerial and ground spray application, or in runoff from rainfall events and through irrigation waters (chemigation). Pendimethalin is not regulated under the Safe Drinking Water Act (SDWA), therefore, an MCL has not been established for it. Pendimethalin has been classified as a Group C nonquantifiable carcinogen by the HED Carcinogenicity Peer Review Committee (RCAB risk assessment summary, 1/17/96). Pendimethalin has been detected in surface water samples at concentrations of <0.01 ppb (µg/L) to approximately 3 ppb (µg/L), and two additional higher values of 10 and 17.6 ppb (µg/L). The high affinity for pendimethalin to bind to soil and sediment particles, should limit concentrations of pendimethalin in surface waters.

The high Kd and Koc values demonstrate that pendimethalin will bind strongly to soil organic matter and is not mobile. EFED concludes that pendimethalin has a low potential to leach to ground water in most soils. Pendimethalin has a history of high use over a wide geographic area on several major crops, however the number of reported detections in ground water is small and the concentrations are relatively low. Pendimethalin residues in drinking water do not appear to be a human health concern. Pendimethalin residues originating from ground water also do not appear to be a concern to organisms such as aquatic plant, terrestrial plants, birds, fish and most aquatic invertebrates. The potential for ground water contamination from pendimethalin residues is low and the potential risk from residues in drinking water is low.

Risk to Nontarget Species:

According to the registrant, the typical application rate for the major uses of pendimehtalin is 2 lbs ai/A. Except for the avian chronic risk which could not be determined, generally at this rate there is expected to be minimal acute risk to birds, minimal acute and chronic risk to fish and aquatic invertebrates, minimal acute risk to estuarine organisms and moderate risk to plants. Use rates higher than 2 lb ai/A are less than 10% or 2,000,000 lbs of pendimethalin total usage. These use rates did result in some LOC exceedances.

Birds: The *acute* risk to birds from pendimethalin is low. The risk quotients (RQs) do not exceed the levels of concern (LOCs) for potentially high acute risk or restricted use. The avian endangered species LOC has been slightly exceeded for the turf and other uses with application rates of 3.0 lbs ai/A or higher. The slight exceedance (RQ of 0.2 compared to LOC of 0.1) was based on the maximum residues from the application rates of 3.0 and 4.0 lbs ai/A on short grasses. The species that may be affected would be primarily grazers (e.g. geese).

According to the registrant, the typical application rate for most usages of pendimethalin is 2 lbs ai/A. The avian acute RQs from this rate does not exceed any LOCs. Thus the typical usage of pendimethalin is considered to represent minimal acute risk to birds.

Chronic risk to avian species cannot be determined because avian reproduction studies have not been submitted. Avian reproduction studies (preferably with the bobwhite quail and the mallard duck) are requested.

Mammals: Both the *acute* and *chronic* risk to mammals, including endangered species, is expected to be minimal. In a 2-generation reproductive toxicity study in rats a NOEL of 2500 ppm was reported. This NOEL is much higher than the maximum EEC of 960 ppm, therefore, it is unlikely that animals would be exposed to pendimethalin residues high enough to cause adverse effects.

Fish and Aquatic Invertebrates: The overall risk to nontarget aquatic animals from pendimethalin is low.

Fish: The LOC for *acute* effects to endangered freshwater fish species was equalled, or exceeded by small margins, by all use sites that are treated aerially at 2 lbs ai/A or higher (RQs ranged from 0.05 to 0.22 compared to the LOC of 0.05), indicating a possibility of effects. All use sites with applications greater than 2.0 lbs ai/A would exceed the endangered fish LOC. A single ground application of pendimethalin at 2 lbs ai/A or lower would not exceed any LOCs and represents minimal acute risk to fish. Application to rice (1.0 lb ai/A) by either air or ground would not exceed any fish LOCs.

Application to onions (three time at 2 lbs ai/A) by air results in RQs that exceeds the restricted use LOC for fish.

The *chronic* risk LOC for fish was exceeded by a small margin (RQ of 1.1 compared to the LOC of 1) by aerial use of pendimethalin on onions. This exceedance was based the 56-day average GEEC of 9 ppb (µg/L). Pendimethalin use on onions is considered to represent a low chronic risk to fish. All other use patterns represent minimal chronic risk to fish.

Freshwater invertebrates: *Acute* risk to freshwater aquatic invertebrates tends to be lower than for fish since pendimethalin is less acutely toxic to these organisms. Applications at 2 lbs ai/A, whether by air or ground, did not exceed any LOCs. Applications greater than 2 lbs ai/A, or multiple applications of 2 lbs ai/A yielded RQs that exceeded the endangered invertebrate LOC by a small margin indicating the possibility of effects to endangered invertebrates, including mollusks. Aerial treatment of onions (three applications at 2 lbs ai/A) resulted in an RQ that exceeded the restricted use LOC by a small margin (0.14 compared to an LOC of 0.1).

Chronic risk to freshwater aquatic invertebrates is expected to be minimal since the chronic Rqs did not exceed the LOC for chronic effects for all uses.

Estuarine organisms: Pendimethalin represents minimal acute risk to estuarine fish and shrimp. Based on toxicity to the eastern oysters, the endangered species LOC is exceeded by small margins (0.06 to 0.14 compared to and LOC of 0.05) from application rates greater than 2 lbs ai/A, or multiple applications at 2 lbs ai/A. Currently, there are no endangered estuarine species of mollusks.

Terrestrial and Semi-aquatic Plants: The risk to nontarget terrestrial and semi-aquatic plants is predicted to be moderate. The RQs are as high as 30 for emerging seedlings. The LOCs have been exceeded for both ground and aerial applications based on the application rate of 2.0 - 4.0 lbs ai/A. This indicates that exposure of pendimethalin from runoff and spray drift will pose risk to the emergence of nontarget plants. Spray drift from aerial applications above 2 lbs ai/A represent a risk to the vigor of mature plants (RQ of 2.8 to 6 compared to LOC of 1). Pendimethalin may also affect endangered terrestrial and semi-aquatic plant species.

Pendimethalin, because of its extensive usage has the potential to exert impact on a large area of nontarget flora. This risk identified would be confined to areas around application sites, i.e. within the drift and runoff zone. Offsite movement from volatilization may also result in risk to plants, but the exposure levels could not be estimated.

It is also noteworthy that the magnitude of RQs, while exceeding the LOC by sizeable margins, are not as high as other herbicides.

Thus, it is presumed that pendimethalin represents a moderate risk to nontarget terrestrial and semi-aquatic plants. This is a balance of LOC exceedances that are not particularly high and extensive usage.

Aquatic Plants: The LOC for risk to nontarget aquatic plants has been exceeded. Risk may be a little higher for nonvascular aquatic plants (diatoms and algae; RQs from 1.3 to 6) than for vascular plants (*L. gibba*; RQs from 0.6 to 2.5). However, based on the magnitude of RQs, the overall risk to aquatic plants is considered to be moderate.

Additional Discussion on Aquatic Risk of Pendimethalin

Additional information on pendimethalin that affects the determination of risk to aquatic organisms include its tendency to bind to sediment and suspended particulates, monitoring results, and typical application rates.

Because of its environmental fate characteristics, once pendimethalin reaches surface water habitats, it will tend to bind to sediment and suspended particulates. The strength of this binding increases with time as is evidenced by the methods required to extract pendimethalin from soil or sediment. This should limit long term concentrations in solution in surface waters.

The presumption that concentrations in surface water systems are limited is supported by monitoring results. In a study of the spatial and temporal distributions of pesticides and nutrients in the Mississippi River and its tributaries, Coupe et al. (1993) did not detect dissolved pendimethalin in surface water samples above the reporting limit of 0.018 µg/L. These study results suggest pendimethalin may not be present in the aqueous phase in concentrations above 0.018 ppb (µg/L). In monitoring reported by Baker (1988) from 1982 to 1985, the residues in Ohio creeks and rivers did not exceed 3.6 ppb (µg/L), and were typically less than 1 ppb (µg/L). The lowest toxicological endpoints for freshwater aquatic organism are the fish full life cycle MATC of 7.85 ppb (µg/L) and the EC50 for Duckweed (*Lemna gibba*) of 12.5 ppb (µg/L). The reported levels from monitoring do not represent a high risk to aquatic organisms.

Finally, it is noted that while several use sites are labeled for use rates greater than 2 lbs ai/A, the typical application rate for most sites is 2 lbs ai/A, according to the registrant. The exceptions are ornamentals (3.0 lbs ai/A), landscape and grounds maintenance, non-cropland (4.0 lbs ai/A) and a few agricultural crops that have higher seasonal rates (e.g. onions; 6 lbs ai/A per season). According to the registrant information, less than 200,000 lbs of pendimethalin are applied to these "higher application rate" use sites annually. Thus, less than one percent of pendimethalin usage is typically at rates greater than 2 lbs ai/A.

Monitoring information indicates that pendimethalin residues are present in surface water. However, EFED concludes that these concentrations do not represent a high risk to aquatic animals and plants, including estuarine organisms.

Discussion of aquatic risk from other use sites for which GENEEC was not used.

Rice: Although pendimethalin is labelled for use on rice, EECs were not calculated for this use since GENEEC was not intended for rice use. The use rate for rice is 1.0 lbs ai/A, which is less than for cotton. Thus, the EECs calculated for cotton would probably be greater than the maximum exposure expected from rice. Pendimethalin is applied directly to the soil of the rice fields; there is no application to water. Labelling specifically states that no floodwater should be on the field at time of application. Once it has been applied, the labeling recommends either rainfall or irrigation to occur within 7 days for pendimethalin to be most effective. The field is then flooded within 5-7 days after seeding and is flushed approximately 90 days later. Virtually all of the water is contained within the rice field, except that which is lost during storm/rainfall events. What is lost during these events constitutes mainly water, with little or no sediment. Based on the environmental fate characteristics, pendimethalin is expected to be sorbed to the sediment and soil particles, and would not be found in the water column. If any soil is lost during these events, the pendimethalin in the water column would tend to sorb to the sediment and soil with which it comes into contact. Therefore, there are reasons to conclude the EECs from rice would be less than those calculated for cotton.

Other use sites: Aquatic EEC's were not estimated for *turf, ornamental, landscape & grounds*

maintenance, non-cropland, and nonbearing nuts and vines (use rates of 3 and 4 lbs ai/A, ground application only). GENEEC is a model designed specifically to model runoff from certain agricultural fields and the risk assessment team did not consider it appropriate for sites such as these. It is assumed, for assessment purposes, that exposure from these use patterns would not be higher than exposure from other uses where GENEEC was used to estimate exposure. This is because these use sites are typically composed of uniformly treated areas much smaller than the 10 hectare watershed used for GENEEC. On turf, where treated sites could be larger than 10 hectares, soil erosion is expected to be minimal. When pendimethalin moves in runoff, it is primarily with suspended soil particles, therefore, surface water exposure from turf is predicted to be less than from agricultural fields. Therefore, aquatic risk from turf, ornamental, landscape & grounds maintenance, non-cropland, and nonbearing nuts and vines (use rates of 3 and 4 lbs ai/A, ground application only) is not expected to be greater than from agricultural use sites with similar application rates.

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Appendix F

CONTAMINATION TESTING RESULTS

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Analytical Report Number : 22-45189

Project / Site name:	Surfleet	**Samples received on:**	11/03/2022
Your job number:	R21071	**Samples instructed on/ Analysis started on:**	11/03/2022
Your order number:		**Analysis completed by:**	29/03/2022
Report Issue Number:	1	**Report issued on:**	30/03/2022
Samples Analysed:	7 soil samples		

Signed:

Anna Goc
Technical Reviewer (Reporting Team)
For & on behalf of i2 Analytical Ltd.

Standard Geotechnical, Asbestos and Chemical Testing Laboratory located at: ul. Pionierów 39, 41 -711 Ruda Śląska, Poland.

Accredited tests are defined within the report, opinions and interpretations expressed herein are outside the scope of accreditation.

Standard sample disposal times, unless otherwise agreed with the laboratory, are :

soils	- 4 weeks from reporting
leachates	- 2 weeks from reporting
waters	- 2 weeks from reporting
asbestos	- 6 months from reporting

Excel copies of reports are only valid when accompanied by this PDF certificate.

Any assessments of compliance with specifications are based on actual analytical results with no contribution from uncertainty of measurement.
Application of uncertainty of measurement would provide a range within which the true result lies.
An estimate of measurement uncertainty can be provided on request.

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The results included within the report are representative of the samples submitted for analysis.

Analytical Report Number: 22-45189
Project / Site name: Surfleet

Lab Sample Number				2202942	2202943	2202944	2202945	2202946
Sample Reference				HP1	HP2	WS1	WS2	WS4
Sample Number				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Depth (m)				0.05	0.30	0.10	0.30	0.25
Date Sampled				09/03/2022	09/03/2022	09/03/2022	09/03/2022	09/03/2022
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Stone Content	%	0.1	NONE	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Moisture Content	%	0.01	NONE	9.5	15	14	12	14
Total mass of sample received	kg	0.001	NONE	0.1	0.3	0.5	0.5	0.5
Asbestos in Soil	Type	N/A	ISO 17025	Not-detected	Not-detected	Not-detected	Not-detected	Not-detected
Asbestos Analyst ID	N/A	N/A	N/A	JSW	JSW	JSW	JSW	JSW
General Inorganics								
pH - Automated	pH Units	N/A	MCERTS	8.3	8.4	8.1	8.2	8.6
Total Cyanide	mg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Organic Matter (automated)	%	0.1	MCERTS	3.5	2.7	2.9	2	1.4
Speciated PAHs								
Naphthalene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Acenaphthylene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Acenaphthene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Fluorene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Phenanthrene	mg/kg	0.05	MCERTS	< 0.05	0.44	< 0.05	< 0.05	< 0.05
Anthracene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Fluoranthene	mg/kg	0.05	MCERTS	< 0.05	0.63	0.33	< 0.05	< 0.05
Pyrene	mg/kg	0.05	MCERTS	< 0.05	0.54	0.31	< 0.05	< 0.05
Benzo(a)anthracene	mg/kg	0.05	MCERTS	< 0.05	0.26	< 0.05	< 0.05	< 0.05
Chrysene	mg/kg	0.05	MCERTS	< 0.05	0.37	< 0.05	< 0.05	< 0.05
Benzo(b)fluoranthene	mg/kg	0.05	MCERTS	< 0.05	0.3	< 0.05	< 0.05	< 0.05
Benzo(k)fluoranthene	mg/kg	0.05	MCERTS	< 0.05	0.25	< 0.05	< 0.05	< 0.05
Benzo(a)pyrene	mg/kg	0.05	MCERTS	< 0.05	0.23	< 0.05	< 0.05	< 0.05
Indeno(1,2,3-cd)pyrene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Dibenz(a,h)anthracene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Benzo(ghi)perylene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Total PAH								
Speciated Total EPA-16 PAHs	mg/kg	0.8	MCERTS	< 0.80	3.02	< 0.80	< 0.80	< 0.80
Heavy Metals / Metalloids								
Arsenic (aqua regia extractable)	mg/kg	1	MCERTS	15	13	19	18	10
Cadmium (aqua regia extractable)	mg/kg	0.2	MCERTS	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Chromium (hexavalent)	mg/kg	4	NONE	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0
Chromium (aqua regia extractable)	mg/kg	1	MCERTS	18	20	25	20	17
Copper (aqua regia extractable)	mg/kg	1	MCERTS	56	18	27	20	14
Lead (aqua regia extractable)	mg/kg	1	MCERTS	39	23	33	28	27
Mercury (aqua regia extractable)	mg/kg	0.3	MCERTS	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Nickel (aqua regia extractable)	mg/kg	1	MCERTS	14	16	15	13	14
Selenium (aqua regia extractable)	mg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Vanadium (aqua regia extractable)	mg/kg	1	MCERTS	27	31	29	27	26
Zinc (aqua regia extractable)	mg/kg	1	MCERTS	90	58	87	66	56

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Analytical Report Number: 22-45189
Project / Site name: Surfleet

Lab Sample Number				2202942	2202943	2202944	2202945	2202946
Sample Reference				HP1	HP2	WS1	WS2	WS4
Sample Number				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Depth (m)				0.05	0.30	0.10	0.30	0.25
Date Sampled				09/03/2022	09/03/2022	09/03/2022	09/03/2022	09/03/2022
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Monoaromatics & Oxygenates								
Benzene	µg/kg	1	MCERTS	-	< 1.0	-	-	-
Toluene	µg/kg	1	MCERTS	-	< 1.0	-	-	-
Ethylbenzene	µg/kg	1	MCERTS	-	< 1.0	-	-	-
p & m-xylene	µg/kg	1	MCERTS	-	< 1.0	-	-	-
o-xylene	µg/kg	1	MCERTS	-	< 1.0	-	-	-
MTBE (Methyl Tertiary Butyl Ether)	µg/kg	1	MCERTS	-	< 1.0	-	-	-
Petroleum Hydrocarbons								
TPH-CWG - Aliphatic >EC5 - EC6 $_{HS_1D_AL}$	mg/kg	0.001	MCERTS	-	< 0.001	-	-	-
TPH-CWG - Aliphatic >EC6 - EC8 $_{HS_1D_AL}$	mg/kg	0.001	MCERTS	-	< 0.001	-	-	-
TPH-CWG - Aliphatic >EC8 - EC10 $_{HS_1D_AL}$	mg/kg	0.001	MCERTS	-	< 0.001	-	-	-
TPH-CWG - Aliphatic >EC10 - EC12 $_{EH_CU_1D_AL}$	mg/kg	1	MCERTS	-	< 1.0	-	-	-
TPH-CWG - Aliphatic >EC12 - EC16 $_{EH_CU_1D_AL}$	mg/kg	2	MCERTS	-	< 2.0	-	-	-
TPH-CWG - Aliphatic >EC16 - EC21 $_{EH_CU_1D_AL}$	mg/kg	8	MCERTS	-	< 8.0	-	-	-
TPH-CWG - Aliphatic >EC21 - EC35 $_{EH_CU_1D_AL}$	mg/kg	8	MCERTS	-	< 8.0	-	-	-
TPH-CWG - Aliphatic (EC5 - EC35) $_{EH_CU+HS_1D_AL}$	mg/kg	10	MCERTS	-	< 10	-	-	-
TPH-CWG - Aromatic >EC5 - EC7 $_{HS_1D_AR}$	mg/kg	0.001	MCERTS	-	< 0.001	-	-	-
TPH-CWG - Aromatic >EC7 - EC8 $_{HS_1D_AR}$	mg/kg	0.001	MCERTS	-	< 0.001	-	-	-
TPH-CWG - Aromatic >EC8 - EC10 $_{HS_1D_AR}$	mg/kg	0.001	MCERTS	-	< 0.001	-	-	-
TPH-CWG - Aromatic >EC10 - EC12 $_{EH_CU_1D_AR}$	mg/kg	1	MCERTS	-	< 1.0	-	-	-
TPH-CWG - Aromatic >EC12 - EC16 $_{EH_CU_1D_AR}$	mg/kg	2	MCERTS	-	< 2.0	-	-	-
TPH-CWG - Aromatic >EC16 - EC21 $_{EH_CU_1D_AR}$	mg/kg	10	MCERTS	-	< 10	-	-	-
TPH-CWG - Aromatic >EC21 - EC35 $_{EH_CU_1D_AR}$	mg/kg	10	MCERTS	-	< 10	-	-	-
TPH-CWG - Aromatic (EC5 - EC35) $_{EH_CU+HS_1D_AR}$	mg/kg	10	MCERTS	-	< 10	-	-	-
SVOCs								
Aniline	mg/kg	0.1	NONE	-	< 0.1	-	-	-
Phenol	mg/kg	0.2	ISO 17025	-	< 0.2	-	-	-
2-Chlorophenol	mg/kg	0.1	MCERTS	-	< 0.1	-	-	-
Bis(2-chloroethyl)ether	mg/kg	0.2	MCERTS	-	< 0.2	-	-	-
1,3-Dichlorobenzene	mg/kg	0.2	MCERTS	-	< 0.2	-	-	-
1,2-Dichlorobenzene	mg/kg	0.1	MCERTS	-	< 0.1	-	-	-
1,4-Dichlorobenzene	mg/kg	0.2	MCERTS	-	< 0.2	-	-	-
Bis(2-chloroisopropyl)ether	mg/kg	0.1	MCERTS	-	< 0.1	-	-	-
2-Methylphenol	mg/kg	0.3	MCERTS	-	< 0.3	-	-	-
Hexachloroethane	mg/kg	0.05	MCERTS	-	< 0.05	-	-	-
Nitrobenzene	mg/kg	0.3	MCERTS	-	< 0.3	-	-	-
4-Methylphenol	mg/kg	0.2	NONE	-	< 0.2	-	-	-
Isophorone	mg/kg	0.2	MCERTS	-	< 0.2	-	-	-
2-Nitrophenol	mg/kg	0.3	MCERTS	-	< 0.3	-	-	-
2,4-Dimethylphenol	mg/kg	0.3	MCERTS	-	< 0.3	-	-	-
Bis(2-chloroethoxy)methane	mg/kg	0.3	MCERTS	-	< 0.3	-	-	-
1,2,4-Trichlorobenzene	mg/kg	0.3	MCERTS	-	< 0.3	-	-	-
Naphthalene	mg/kg	0.05	MCERTS	-	< 0.05	-	-	-
2,4-Dichlorophenol	mg/kg	0.3	MCERTS	-	< 0.3	-	-	-
4-Chloroaniline	mg/kg	0.1	NONE	-	< 0.1	-	-	-
Hexachlorobutadiene	mg/kg	0.1	MCERTS	-	< 0.1	-	-	-
4-Chloro-3-methylphenol	mg/kg	0.1	NONE	-	< 0.1	-	-	-
2,4,6-Trichlorophenol	mg/kg	0.1	MCERTS	-	< 0.1	-	-	-
2,4,5-Trichlorophenol	mg/kg	0.2	MCERTS	-	< 0.2	-	-	-
2-Methylnaphthalene	mg/kg	0.1	NONE	-	< 0.1	-	-	-

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Analytical Report Number: 22-45189
Project / Site name: Surfleet

Lab Sample Number				2202942	2202943	2202944	2202945	2202946
Sample Reference				HP1	HP2	WS1	WS2	WS4
Sample Number				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Depth (m)				0.05	0.30	0.10	0.30	0.25
Date Sampled				09/03/2022	09/03/2022	09/03/2022	09/03/2022	09/03/2022
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
2-Chloronaphthalene	mg/kg	0.1	MCERTS	-	< 0.1	-	-	-
Dimethylphthalate	mg/kg	0.1	MCERTS	-	< 0.1	-	-	-
2,6-Dinitrotoluene	mg/kg	0.1	MCERTS	-	< 0.1	-	-	-
Acenaphthylene	mg/kg	0.05	MCERTS	-	< 0.05	-	-	-
Acenaphthene	mg/kg	0.05	MCERTS	-	< 0.05	-	-	-
2,4-Dinitrotoluene	mg/kg	0.2	MCERTS	-	< 0.2	-	-	-
Dibenzofuran	mg/kg	0.2	MCERTS	-	< 0.2	-	-	-
4-Chlorophenyl phenyl ether	mg/kg	0.3	ISO 17025	-	< 0.3	-	-	-
Diethyl phthalate	mg/kg	0.2	MCERTS	-	< 0.2	-	-	-
4-Nitroaniline	mg/kg	0.2	MCERTS	-	< 0.2	-	-	-
Fluorene	mg/kg	0.05	MCERTS	-	< 0.05	-	-	-
Azobenzene	mg/kg	0.3	MCERTS	-	< 0.3	-	-	-
Bromophenyl phenyl ether	mg/kg	0.2	MCERTS	-	< 0.2	-	-	-
Hexachlorobenzene	mg/kg	0.3	MCERTS	-	< 0.3	-	-	-
Phenanthrene	mg/kg	0.05	MCERTS	-	0.44	-	-	-
Anthracene	mg/kg	0.05	MCERTS	-	< 0.05	-	-	-
Carbazole	mg/kg	0.3	MCERTS	-	< 0.3	-	-	-
Dibutyl phthalate	mg/kg	0.2	MCERTS	-	< 0.2	-	-	-
Anthraquinone	mg/kg	0.3	MCERTS	-	< 0.3	-	-	-
Fluoranthene	mg/kg	0.05	MCERTS	-	0.63	-	-	-
Pyrene	mg/kg	0.05	MCERTS	-	0.54	-	-	-
Butyl benzyl phthalate	mg/kg	0.3	ISO 17025	-	< 0.3	-	-	-
Benzo(a)anthracene	mg/kg	0.05	MCERTS	-	0.26	-	-	-
Chrysene	mg/kg	0.05	MCERTS	-	0.37	-	-	-
Benzo(b)fluoranthene	mg/kg	0.05	MCERTS	-	0.3	-	-	-
Benzo(k)fluoranthene	mg/kg	0.05	MCERTS	-	0.25	-	-	-
Benzo(a)pyrene	mg/kg	0.05	MCERTS	-	0.23	-	-	-
Indeno(1,2,3-cd)pyrene	mg/kg	0.05	MCERTS	-	< 0.05	-	-	-
Dibenz(a,h)anthracene	mg/kg	0.05	MCERTS	-	< 0.05	-	-	-
Benzo(ghi)perylene	mg/kg	0.05	MCERTS	-	< 0.05	-	-	-
Pesticides								
Alachlor	µg/kg	10	NONE	-	-	< 10	-	-
Aldrin	µg/kg	10	NONE	-	-	< 10	-	-
Azinphos-ethyl	µg/kg	10	NONE	-	-	< 10	-	-
Azinphos-methyl	µg/kg	10	NONE	-	-	< 10	-	-
BHC-alpha (benzene hexachloride)	µg/kg	10	NONE	-	-	< 10	-	-
BHC-beta	µg/kg	10	NONE	-	-	< 10	-	-
BHC-delta	µg/kg	10	NONE	-	-	< 10	-	-
BHC-gamma (Lindane, gamma HCH)	µg/kg	10	NONE	-	-	< 10	-	-
Bifenthrin	µg/kg	10	NONE	-	-	< 10	-	-
Carbophenothion	µg/kg	10	NONE	-	-	< 10	-	-
Chlordane-cis	µg/kg	10	NONE	-	-	< 10	-	-
Chlordane-trans	µg/kg	10	NONE	-	-	< 10	-	-
Chlorfenvinphos	µg/kg	10	NONE	-	-	< 10	-	-
Chlorothalonil	µg/kg	20	NONE	-	-	< 20	-	-
Chlorpyrifos	µg/kg	10	NONE	-	-	< 10	-	-
Cyfluthrin (Sum)	µg/kg	10	NONE	-	-	< 10	-	-
Cyhalothrin (Lambda)	µg/kg	10	NONE	-	-	< 10	-	-
Cypermethrin (Sum)	µg/kg	10	NONE	-	-	< 10	-	-
DDD-o,p'	µg/kg	10	NONE	-	-	< 10	-	-
DDD-p,p'	µg/kg	10	NONE	-	-	33	-	-
DDE-o,p'	µg/kg	10	NONE	-	-	< 10	-	-

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Analytical Report Number: 22-45189
Project / Site name: Surfleet

Lab Sample Number				2202942	2202943	2202944	2202945	2202946
Sample Reference				HP1	HP2	WS1	WS2	WS4
Sample Number				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Depth (m)				0.05	0.30	0.10	0.30	0.25
Date Sampled				09/03/2022	09/03/2022	09/03/2022	09/03/2022	09/03/2022
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
DDE-p,p'	µg/kg	10	NONE	-	-	44	-	-
DDT-o,p'	µg/kg	10	NONE	-	-	< 10	-	-
DDT-p,p'	µg/kg	10	NONE	-	-	24	-	-
Deltamethrin	µg/kg	10	NONE	-	-	< 10	-	-
Demeton-O	µg/kg	10	NONE	-	-	< 10	-	-
Demeton-S	µg/kg	10	NONE	-	-	< 10	-	-
Diazinon	µg/kg	10	NONE	-	-	< 10	-	-
Dichlorobenzonitrile, 2,6-	µg/kg	10	NONE	-	-	< 10	-	-
Dichlorvos	µg/kg	10	NONE	-	-	< 10	-	-
Dieldrin	µg/kg	10	NONE	-	-	< 10	-	-
Dimethoate	µg/kg	10	NONE	-	-	< 10	-	-
Dimethylvinphos	µg/kg	10	NONE	-	-	< 10	-	-
Endosulfan I (alpha isomer)	µg/kg	10	NONE	-	-	< 10	-	-
Endosulfan II (beta isomer)	µg/kg	10	NONE	-	-	< 10	-	-
Endosulfan sulfate	µg/kg	10	NONE	-	-	< 10	-	-
Endrin	µg/kg	20	NONE	-	-	< 20	-	-
Endrin aldehyde	µg/kg	10	NONE	-	-	< 10	-	-
Endrin ketone	µg/kg	10	NONE	-	-	< 10	-	-
Ethion	µg/kg	10	NONE	-	-	< 10	-	-
Etrimfos	µg/kg	10	NONE	-	-	< 10	-	-
Fenitrothion	µg/kg	10	NONE	-	-	< 10	-	-
Fenthion	µg/kg	10	NONE	-	-	< 10	-	-
Fenvalerate (Sum)	µg/kg	10	NONE	-	-	< 10	-	-
Heptachlor	µg/kg	10	NONE	-	-	< 10	-	-
Heptachlor exo-epoxide	µg/kg	10	NONE	-	-	< 10	-	-
Hexachlorobenzene	µg/kg	10	NONE	-	-	< 10	-	-
Hexachlorobutadiene	µg/kg	10	NONE	-	-	< 10	-	-
Isodrin	µg/kg	20	NONE	-	-	< 20	-	-
Malathion	µg/kg	10	NONE	-	-	< 10	-	-
Methacrifos	µg/kg	10	NONE	-	-	< 10	-	-
Methoxychlor, p,p'-	µg/kg	20	NONE	-	-	< 20	-	-
Mevinphos, E+Z	µg/kg	10	NONE	-	-	< 10	-	-
Omethoate	µg/kg	20	NONE	-	-	< 20	-	-
Parathion	µg/kg	10	NONE	-	-	< 10	-	-
Parathion-methyl	µg/kg	10	NONE	-	-	< 10	-	-
Pendimethalin	µg/kg	10	NONE	-	-	15	-	-
Pentachlorobenzene	µg/kg	10	NONE	-	-	< 10	-	-
Permethrin, Cis-	µg/kg	10	NONE	-	-	< 10	-	-
Permethrin, Trans-	µg/kg	10	NONE	-	-	< 10	-	-
Phorate	µg/kg	10	NONE	-	-	< 10	-	-
Phosalone	µg/kg	10	NONE	-	-	< 10	-	-
Phosphamidon (Sum)	µg/kg	10	NONE	-	-	< 10	-	-
Pirimiphos-ethyl	µg/kg	10	NONE	-	-	< 10	-	-
Pirimiphos-methyl	µg/kg	10	NONE	-	-	< 10	-	-
Propetamphos	µg/kg	10	NONE	-	-	< 10	-	-
Propyzamide	µg/kg	10	NONE	-	-	< 10	-	-
Tecnazene	µg/kg	10	NONE	-	-	< 10	-	-
Tetrachlorobenzene, 1,2,4,5-	µg/kg	10	NONE	-	-	< 10	-	-
Trichlorobenzene, 1,2,3-	µg/kg	10	NONE	-	-	< 10	-	-
Trichlorobenzene, 1,3,5-	µg/kg	10	NONE	-	-	< 10	-	-
Trifluralin	µg/kg	10	NONE	-	-	< 10	-	-

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Analytical Report Number: 22-45189
Project / Site name: Surfleet

Lab Sample Number				2202942	2202943	2202944	2202945	2202946
Sample Reference				HP1	HP2	WS1	WS2	WS4
Sample Number				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Depth (m)				0.05	0.30	0.10	0.30	0.25
Date Sampled				09/03/2022	09/03/2022	09/03/2022	09/03/2022	09/03/2022
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Dioxins & Furans (Subcontracted)								
Dioxins & Furans (Subcontracted)		N/A	NONE	See Attached	-	-	-	-

U/S = Unsuitable Sample I/S = Insufficient Sample

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Analytical Report Number: 22-45189
Project / Site name: Surfleet

Lab Sample Number				2202947	2202948
Sample Reference				WS3	WS5
Sample Number				None Supplied	None Supplied
Depth (m)				0.15	0.05
Date Sampled				09/03/2022	09/03/2022
Time Taken				None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**		
Stone Content	%	0.1	NONE	< 0.1	< 0.1
Moisture Content	%	0.01	NONE	12	9.5
Total mass of sample received	kg	0.001	NONE	0.5	0.5
Asbestos in Soil	Type	N/A	ISO 17025	Not-detected	Not-detected
Asbestos Analyst ID	N/A	N/A	N/A	JSW	JSW
General Inorganics					
pH - Automated	pH Units	N/A	MCERTS	8.2	8.5
Total Cyanide	mg/kg	1	MCERTS	< 1.0	< 1.0
Organic Matter (automated)	%	0.1	MCERTS	2.3	1.3
Speciated PAHs					
Naphthalene	mg/kg	0.05	MCERTS	< 0.05	< 0.05
Acenaphthylene	mg/kg	0.05	MCERTS	< 0.05	< 0.05
Acenaphthene	mg/kg	0.05	MCERTS	< 0.05	< 0.05
Fluorene	mg/kg	0.05	MCERTS	< 0.05	< 0.05
Phenanthrene	mg/kg	0.05	MCERTS	< 0.05	< 0.05
Anthracene	mg/kg	0.05	MCERTS	< 0.05	< 0.05
Fluoranthene	mg/kg	0.05	MCERTS	< 0.05	< 0.05
Pyrene	mg/kg	0.05	MCERTS	< 0.05	< 0.05
Benzo(a)anthracene	mg/kg	0.05	MCERTS	< 0.05	< 0.05
Chrysene	mg/kg	0.05	MCERTS	< 0.05	< 0.05
Benzo(b)fluoranthene	mg/kg	0.05	MCERTS	< 0.05	< 0.05
Benzo(k)fluoranthene	mg/kg	0.05	MCERTS	< 0.05	< 0.05
Benzo(a)pyrene	mg/kg	0.05	MCERTS	< 0.05	< 0.05
Indeno(1,2,3-cd)pyrene	mg/kg	0.05	MCERTS	< 0.05	< 0.05
Dibenz(a,h)anthracene	mg/kg	0.05	MCERTS	< 0.05	< 0.05
Benzo(ghi)perylene	mg/kg	0.05	MCERTS	< 0.05	< 0.05
Total PAH					
Speciated Total EPA-16 PAHs	mg/kg	0.8	MCERTS	< 0.80	< 0.80
Heavy Metals / Metalloids					
Arsenic (aqua regia extractable)	mg/kg	1	MCERTS	18	14
Cadmium (aqua regia extractable)	mg/kg	0.2	MCERTS	< 0.2	< 0.2
Chromium (hexavalent)	mg/kg	4	NONE	< 4.0	< 4.0
Chromium (aqua regia extractable)	mg/kg	1	MCERTS	25	16
Copper (aqua regia extractable)	mg/kg	1	MCERTS	22	18
Lead (aqua regia extractable)	mg/kg	1	MCERTS	36	16
Mercury (aqua regia extractable)	mg/kg	0.3	MCERTS	< 0.3	< 0.3
Nickel (aqua regia extractable)	mg/kg	1	MCERTS	15	17
Selenium (aqua regia extractable)	mg/kg	1	MCERTS	< 1.0	< 1.0
Vanadium (aqua regia extractable)	mg/kg	1	MCERTS	28	29
Zinc (aqua regia extractable)	mg/kg	1	MCERTS	88	77

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Analytical Report Number: 22-45189
Project / Site name: Surfleet

Lab Sample Number				2202947	2202948
Sample Reference				WS3	WS5
Sample Number				None Supplied	None Supplied
Depth (m)				0.15	0.05
Date Sampled				09/03/2022	09/03/2022
Time Taken				None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**		
Monoaromatics & Oxygenates					
Benzene	µg/kg	1	MCERTS	-	-
Toluene	µg/kg	1	MCERTS	-	-
Ethylbenzene	µg/kg	1	MCERTS	-	-
p & m-xylene	µg/kg	1	MCERTS	-	-
o-xylene	µg/kg	1	MCERTS	-	-
MTBE (Methyl Tertiary Butyl Ether)	µg/kg	1	MCERTS	-	-
Petroleum Hydrocarbons					
TPH-CWG - Aliphatic >EC5 - EC6 $_{HS_1D_AL}$	mg/kg	0.001	MCERTS	-	-
TPH-CWG - Aliphatic >EC6 - EC8 $_{HS_1D_AL}$	mg/kg	0.001	MCERTS	-	-
TPH-CWG - Aliphatic >EC8 - EC10 $_{HS_1D_AL}$	mg/kg	0.001	MCERTS	-	-
TPH-CWG - Aliphatic >EC10 - EC12 $_{EH_CU_1D_AL}$	mg/kg	1	MCERTS	-	-
TPH-CWG - Aliphatic >EC12 - EC16 $_{EH_CU_1D_AL}$	mg/kg	2	MCERTS	-	-
TPH-CWG - Aliphatic >EC16 - EC21 $_{EH_CU_1D_AL}$	mg/kg	8	MCERTS	-	-
TPH-CWG - Aliphatic >EC21 - EC35 $_{EH_CU_1D_AL}$	mg/kg	8	MCERTS	-	-
TPH-CWG - Aliphatic (EC5 - EC35) $_{EH_CU+HS_1D_AL}$	mg/kg	10	MCERTS	-	-
TPH-CWG - Aromatic >EC5 - EC7 $_{HS_1D_AR}$	mg/kg	0.001	MCERTS	-	-
TPH-CWG - Aromatic >EC7 - EC8 $_{HS_1D_AR}$	mg/kg	0.001	MCERTS	-	-
TPH-CWG - Aromatic >EC8 - EC10 $_{HS_1D_AR}$	mg/kg	0.001	MCERTS	-	-
TPH-CWG - Aromatic >EC10 - EC12 $_{EH_CU_1D_AR}$	mg/kg	1	MCERTS	-	-
TPH-CWG - Aromatic >EC12 - EC16 $_{EH_CU_1D_AR}$	mg/kg	2	MCERTS	-	-
TPH-CWG - Aromatic >EC16 - EC21 $_{EH_CU_1D_AR}$	mg/kg	10	MCERTS	-	-
TPH-CWG - Aromatic >EC21 - EC35 $_{EH_CU_1D_AR}$	mg/kg	10	MCERTS	-	-
TPH-CWG - Aromatic (EC5 - EC35) $_{EH_CU+HS_1D_AR}$	mg/kg	10	MCERTS	-	-
SVOCs					
Aniline	mg/kg	0.1	NONE	-	-
Phenol	mg/kg	0.2	ISO 17025	-	-
2-Chlorophenol	mg/kg	0.1	MCERTS	-	-
Bis(2-chloroethyl)ether	mg/kg	0.2	MCERTS	-	-
1,3-Dichlorobenzene	mg/kg	0.2	MCERTS	-	-
1,2-Dichlorobenzene	mg/kg	0.1	MCERTS	-	-
1,4-Dichlorobenzene	mg/kg	0.2	MCERTS	-	-
Bis(2-chloroisopropyl)ether	mg/kg	0.1	MCERTS	-	-
2-Methylphenol	mg/kg	0.3	MCERTS	-	-
Hexachloroethane	mg/kg	0.05	MCERTS	-	-
Nitrobenzene	mg/kg	0.3	MCERTS	-	-
4-Methylphenol	mg/kg	0.2	NONE	-	-
Isophorone	mg/kg	0.2	MCERTS	-	-
2-Nitrophenol	mg/kg	0.3	MCERTS	-	-
2,4-Dimethylphenol	mg/kg	0.3	MCERTS	-	-
Bis(2-chloroethoxy)methane	mg/kg	0.3	MCERTS	-	-
1,2,4-Trichlorobenzene	mg/kg	0.3	MCERTS	-	-
Naphthalene	mg/kg	0.05	MCERTS	-	-
2,4-Dichlorophenol	mg/kg	0.3	MCERTS	-	-
4-Chloroaniline	mg/kg	0.1	NONE	-	-
Hexachlorobutadiene	mg/kg	0.1	MCERTS	-	-
4-Chloro-3-methylphenol	mg/kg	0.1	NONE	-	-
2,4,6-Trichlorophenol	mg/kg	0.1	MCERTS	-	-
2,4,5-Trichlorophenol	mg/kg	0.2	MCERTS	-	-
2-Methylnaphthalene	mg/kg	0.1	NONE	-	-

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Analytical Report Number: 22-45189
Project / Site name: Surfleet

Lab Sample Number				2202947	2202948
Sample Reference				WS3	WS5
Sample Number				None Supplied	None Supplied
Depth (m)				0.15	0.05
Date Sampled				09/03/2022	09/03/2022
Time Taken				None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**		
2-Chloronaphthalene	mg/kg	0.1	MCERTS	-	-
Dimethylphthalate	mg/kg	0.1	MCERTS	-	-
2,6-Dinitrotoluene	mg/kg	0.1	MCERTS	-	-
Acenaphthylene	mg/kg	0.05	MCERTS	-	-
Acenaphthene	mg/kg	0.05	MCERTS	-	-
2,4-Dinitrotoluene	mg/kg	0.2	MCERTS	-	-
Dibenzofuran	mg/kg	0.2	MCERTS	-	-
4-Chlorophenyl phenyl ether	mg/kg	0.3	ISO 17025	-	-
Diethyl phthalate	mg/kg	0.2	MCERTS	-	-
4-Nitroaniline	mg/kg	0.2	MCERTS	-	-
Fluorene	mg/kg	0.05	MCERTS	-	-
Azobenzene	mg/kg	0.3	MCERTS	-	-
Bromophenyl phenyl ether	mg/kg	0.2	MCERTS	-	-
Hexachlorobenzene	mg/kg	0.3	MCERTS	-	-
Phenanthrene	mg/kg	0.05	MCERTS	-	-
Anthracene	mg/kg	0.05	MCERTS	-	-
Carbazole	mg/kg	0.3	MCERTS	-	-
Dibutyl phthalate	mg/kg	0.2	MCERTS	-	-
Anthraquinone	mg/kg	0.3	MCERTS	-	-
Fluoranthene	mg/kg	0.05	MCERTS	-	-
Pyrene	mg/kg	0.05	MCERTS	-	-
Butyl benzyl phthalate	mg/kg	0.3	ISO 17025	-	-
Benzo(a)anthracene	mg/kg	0.05	MCERTS	-	-
Chrysene	mg/kg	0.05	MCERTS	-	-
Benzo(b)fluoranthene	mg/kg	0.05	MCERTS	-	-
Benzo(k)fluoranthene	mg/kg	0.05	MCERTS	-	-
Benzo(a)pyrene	mg/kg	0.05	MCERTS	-	-
Indeno(1,2,3-cd)pyrene	mg/kg	0.05	MCERTS	-	-
Dibenz(a,h)anthracene	mg/kg	0.05	MCERTS	-	-
Benzo(ghi)perylene	mg/kg	0.05	MCERTS	-	-
Pesticides					
Alachlor	µg/kg	10	NONE	-	-
Aldrin	µg/kg	10	NONE	-	-
Azinphos-ethyl	µg/kg	10	NONE	-	-
Azinphos-methyl	µg/kg	10	NONE	-	-
BHC-alpha (benzene hexachloride)	µg/kg	10	NONE	-	-
BHC-beta	µg/kg	10	NONE	-	-
BHC-delta	µg/kg	10	NONE	-	-
BHC-gamma (Lindane, gamma HCH)	µg/kg	10	NONE	-	-
Bifenthrin	µg/kg	10	NONE	-	-
Carbophenothion	µg/kg	10	NONE	-	-
Chlordane-cis	µg/kg	10	NONE	-	-
Chlordane-trans	µg/kg	10	NONE	-	-
Chlorfenvinphos	µg/kg	10	NONE	-	-
Chlorothalonil	µg/kg	20	NONE	-	-
Chlorpyrifos	µg/kg	10	NONE	-	-
Cyfluthrin (Sum)	µg/kg	10	NONE	-	-
Cyhalothrin (Lambda)	µg/kg	10	NONE	-	-
Cypermethrin (Sum)	µg/kg	10	NONE	-	-
DDD-o,p'	µg/kg	10	NONE	-	-
DDD-p,p'	µg/kg	10	NONE	-	-
DDE-o,p'	µg/kg	10	NONE	-	-

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Analytical Report Number: 22-45189
Project / Site name: Surfleet

Lab Sample Number				2202947	2202948
Sample Reference				WS3	WS5
Sample Number				None Supplied	None Supplied
Depth (m)				0.15	0.05
Date Sampled				09/03/2022	09/03/2022
Time Taken				None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**		
DDE-p,p'	µg/kg	10	NONE	-	-
DDT-o,p'	µg/kg	10	NONE	-	-
DDT-p,p'	µg/kg	10	NONE	-	-
Deltamethrin	µg/kg	10	NONE	-	-
Demeton-O	µg/kg	10	NONE	-	-
Demeton-S	µg/kg	10	NONE	-	-
Diazinon	µg/kg	10	NONE	-	-
Dichlorobenzonitrile, 2,6-	µg/kg	10	NONE	-	-
Dichlorvos	µg/kg	10	NONE	-	-
Dieldrin	µg/kg	10	NONE	-	-
Dimethoate	µg/kg	10	NONE	-	-
Dimethylvinphos	µg/kg	10	NONE	-	-
Endosulfan I (alpha isomer)	µg/kg	10	NONE	-	-
Endosulfan II (beta isomer)	µg/kg	10	NONE	-	-
Endosulfan sulfate	µg/kg	10	NONE	-	-
Endrin	µg/kg	20	NONE	-	-
Endrin aldehyde	µg/kg	10	NONE	-	-
Endrin ketone	µg/kg	10	NONE	-	-
Ethion	µg/kg	10	NONE	-	-
Etrimfos	µg/kg	10	NONE	-	-
Fenitrothion	µg/kg	10	NONE	-	-
Fenthion	µg/kg	10	NONE	-	-
Fenvalerate (Sum)	µg/kg	10	NONE	-	-
Heptachlor	µg/kg	10	NONE	-	-
Heptachlor exo-epoxide	µg/kg	10	NONE	-	-
Hexachlorobenzene	µg/kg	10	NONE	-	-
Hexachlorobutadiene	µg/kg	10	NONE	-	-
Isodrin	µg/kg	20	NONE	-	-
Malathion	µg/kg	10	NONE	-	-
Methacrifos	µg/kg	10	NONE	-	-
Methoxychlor, p,p'-	µg/kg	20	NONE	-	-
Mevinphos, E+Z	µg/kg	10	NONE	-	-
Omethoate	µg/kg	20	NONE	-	-
Parathion	µg/kg	10	NONE	-	-
Parathion-methyl	µg/kg	10	NONE	-	-
Pendimethalin	µg/kg	10	NONE	-	-
Pentachlorobenzene	µg/kg	10	NONE	-	-
Permethrin, Cis-	µg/kg	10	NONE	-	-
Permethrin, Trans-	µg/kg	10	NONE	-	-
Phorate	µg/kg	10	NONE	-	-
Phosalone	µg/kg	10	NONE	-	-
Phosphamidon (Sum)	µg/kg	10	NONE	-	-
Pirimiphos-ethyl	µg/kg	10	NONE	-	-
Pirimiphos-methyl	µg/kg	10	NONE	-	-
Propetamphos	µg/kg	10	NONE	-	-
Propyzamide	µg/kg	10	NONE	-	-
Tecnazene	µg/kg	10	NONE	-	-
Tetrachlorobenzene, 1,2,4,5-	µg/kg	10	NONE	-	-
Trichlorobenzene, 1,2,3-	µg/kg	10	NONE	-	-
Trichlorobenzene, 1,3,5-	µg/kg	10	NONE	-	-
Trifluralin	µg/kg	10	NONE	-	-

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Analytical Report Number: 22-45189
Project / Site name: Surfleet

Lab Sample Number				2202947	2202948
Sample Reference				WS3	WS5
Sample Number				None Supplied	None Supplied
Depth (m)				0.15	0.05
Date Sampled				09/03/2022	09/03/2022
Time Taken				None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**		
Dioxins & Furans (Subcontracted)					
Dioxins & Furans (Subcontracted)		N/A	NONE	-	-

U/S = Unsuitable Sample I/S = Insufficient Sample

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* These descriptions are only intended to act as a cross check if sample identities are questioned. The major constituent of the sample is intended to act with respect to MCERTS validation. The laboratory is accredited for sand, clay and loam (MCERTS) soil types. Data for unaccredited types of solid should be interpreted with care.

Stone content of a sample is calculated as the % weight of the stones not passing a 10 mm sieve. Results are not corrected for stone content.

Lab Sample Number	Sample Reference	Sample Number	Depth (m)	Sample Description *
2202942	HP1	None Supplied	0.05	Brown clay with gravel and vegetation.
2202943	HP2	None Supplied	0.3	Brown clay and loam with gravel and vegetation.
2202944	WS1	None Supplied	0.1	Brown clay with gravel.
2202945	WS2	None Supplied	0.3	Brown sandy clay.
2202946	WS4	None Supplied	0.25	Brown clay.
2202947	WS3	None Supplied	0.15	Brown clay.
2202948	WS5	None Supplied	0.05	Brown clay and sand with gravel and vegetation.

Analytical Report Number : 22-45189
Project / Site name: Surfleet

Water matrix abbreviations:
Surface Water (SW) Potable Water (PW) Ground Water (GW) Process Waters (PrW) Final Sewage Effluent (FSE) Landfill Leachate (LL)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Metals in soil by ICP-OES	Determination of metals in soil by aqua-regia digestion followed by ICP-OES.	In-house method based on MEWAM 2006 Methods for the Determination of Metals in Soil.	L038-PL	D	MCERTS
Asbestos identification in soil	Asbestos Identification with the use of polarised light microscopy in conjunction with disperion staining techniques.	In house method based on HSG 248	A001-PL	D	ISO 17025
Hexavalent chromium in soil	Determination of hexavalent chromium in soil by extraction in water then by acidification, addition of 1,5 diphenylcarbazide followed by colorimetry.	In-house method	L080-PL	W	NONE
Moisture Content	Moisture content, determined gravimetrically. (30 oC)	In house method.	L019-UK/PL	W	NONE
Speciated EPA-16 PAHs in soil	Determination of PAH compounds in soil by extraction in dichloromethane and hexane followed by GC-MS with the use of surrogate and internal standards.	In-house method based on USEPA 8270	L064-PL	D	MCERTS
pH in soil (automated)	Determination of pH in soil by addition of water followed by automated electrometric measurement.	In house method.	L099-PL	D	MCERTS
Stones content of soil	Standard preparation for all samples unless otherwise detailed. Gravimetric determination of stone > 10 mm as % dry weight.	In-house method based on British Standard Methods and MCERTS requirements.	L019-UK/PL	D	NONE
Semi-volatile organic compounds in soil	Determination of semi-volatile organic compounds in soil by extraction in dichloromethane and hexane followed by GC-MS.	In-house method based on USEPA 8270	L064-PL	D	MCERTS
Total cyanide in soil	Determination of total cyanide by distillation followed by colorimetry.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton (Skalar)	L080-PL	W	MCERTS
BTEX and MTBE in soil (Monoaromatics)	Determination of BTEX in soil by headspace GC-MS.	In-house method based on USEPA8260	L073B-PL	W	MCERTS
TPHCWG (Soil)	Determination of hexane extractable hydrocarbons in soil by GC-MS/GC-FID.	In-house method with silica gel split/clean up.	L088/76-PL	W	MCERTS
Pesticides by GC-MS/MS	Detemination of Pesticides in soil by GC MS/MS	In-house method	L055B-PL	W	NONE
Organic matter (Automated) in soil	Determination of organic matter in soil by oxidising with potassium dichromate followed by titration with iron (II) sulphate.	In house method.	L009-PL	D	MCERTS
Dioxins and Furans in soil	Dioxins and Furans in Soil - Subcontracted Analysis.	Subcontracted Analysis - See Attached Subcon Report.		W	NONE

For method numbers ending in 'UK' analysis have been carried out in our laboratory in the United Kingdom.
For method numbers ending in 'PL' analysis have been carried out in our laboratory in Poland.
Soil analytical results are expressed on a dry weight basis. Where analysis is carried out on as-received the results obtained are multiplied by a moisture correction factor that is determined gravimetrically using the moisture content which is carried out at a maximum of 30oC.

Unless otherwise indicated, site information, order number, project number, sampling date, time, sample reference and depth are provided by the client. The instructed on date indicates the date on which this information was provided to the laboratory.

Information in Support of Analytical Results

Analytical Report Number : 22-45189
Project / Site name: Surfleet

Water matrix abbreviations:
Surface Water (SW) Potable Water (PW) Ground Water (GW) Process Waters (PrW) Final Sewage Effluent (FSE) Landfill Leachate (LL)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status

List of HWOL Acronyms and Operators

Acronym	Descriptions
HS	Headspace Analysis
MS	Mass spectrometry
FID	Flame Ionisation Detector
GC	Gas Chromatography
EH	Extractable Hydrocarbons (i.e. everything extracted by the solvent(s))
CU	Clean-up - e.g. by Florisil®, silica gel
1D	GC - Single coil/column gas chromatography
2D	GC-GC - Double coil/column gas chromatography
Total	Aliphatics & Aromatics
AL	Aliphatics
AR	Aromatics
#1	EH_2D_Total but with humics mathematically subtracted
#2	EH_2D_Total but with fatty acids mathematically subtracted
_	Operator - understore to separate acronyms (exception for +)
+	Operator to indicate cumulative e.g. EH+HS_Total or EH_CU+HS_Total

Marchwood Scientific Services
371 Millbrook Rd West
Southampton
SO15 0HW
Tel: 02380 786979

UKAS accredited testing laboratory No. 1668

Name of Client : I2 Analytical Ltd **Test Certificate No:** 190306
Address : 7 Woodshots Meadow, Croxley Green Business Park, Watford, WD18 8YS

ANALYSIS OF PCDDs and PCDFs

Job Reference: 22-45189
Sample Identifier : 2202942 HP1 0.05
Sample No: 190306
Order No: PO_S_C5334
Sample Type: Soil
Sample Condition : conforming
Instrument : Thermo DFS
GC Column : DB5
Calibration File : 220328

Date of Receipt : 15/03/22
Date of Analysis : 25/03/22
Date of Report : 29/03/22

Test Method : 2002a
Blank : 220321
Sample size: 1

expressed as ng /kg

Congener	Conc	DL	Rec %	Congener	Conc	DL	Rec %
2378-TCDF	1.73	0.427	91	**2378-TCDD**	*	0.265	120
12378-PCDF	0.709	0.223	107	**12378-PCDD**	*	0.330	100
23478-PCDF	1.45	0.254	85	**123478-HxCDD**	*	0.342	97
123478-HxCDF	1.84	0.306	102	**123678-HxCDD**	0.887	0.347	103
123678-HxCDF	1.10	0.294	103	**123789-HxCDD**	1.03	0.337	
234678-HxCDF	2.35	0.305	90	**1234678-HpCDD**	16.1	0.494	90
123789-HxCDF	*	0.338	106	**OCDD**	80.5	0.787	78
1234678-HpCDF	28.3	0.276	93				
1234789-HpCDF	0.894	0.386	87				
OCDF	24.2	0.494					
Total 2,3,7,8-Furans	**62.6**			**Total 2,3,7,8-Dioxins**	**98.5**		

	TEQ^1	TEQ^2		TEQ^1	TEQ^2
TEQ (Nato)	**2.71**	**2.21**	**TEQ (WHO)- Mammals**	**2.50**	**1.84**
			TEQ (WHO)- Fish	**2.51**	**1.71**
			TEQ (WHO)- Birds	**4.86**	**4.21**

*	Isomer Not detected
TEQ	Toxic Equivalent Value
TEF	Toxic Equivalent Factor
Conc	Concentration
DL	Detection Value
REC	Recovery

TEQ^1	Concentration of Non Detected Congeners at Detection Limit
TEQ^2	Concentration of Non Detected Congeners at Zero

Approved by : Rob Potts
Position : Laboratory Manager

Signature :

UKAS TESTING
1668

Appendix G

GROUNDWATER AND GROUND GAS MONITORING RESULTS

Grange Geo GAS AND GROUNDWATER MONITORING

Site:		Surfleet
Client:		
Job No.:		R21071
Date:		17/03/2022
Start / End Time:		11.30am
Engineer:		A.Hare
Monitoring Equipment:	**Gas Meter ID**	**GG001**
	PID ID	
	Dip Tape	**In-Situ 30m**
	Other	

NR = Not Recorded
Dry = No Groundwater

Weather Conditions	Start	End
(Dry / Raining)	dry	dry
Cloud Cover (Oktas)	1/8	1/8
Wind Strength (mph)	13.0	12.0
Wind Direction (from)	NW	NW
Temperature (°C)	11.0	11.0
Barometric Pressure (mb)	1020	1019
(Rising/ Falling)	Falling	
PID - Air	0	
PID - Calibration Gas	100	

Location Reference	Relative Pressure (mbar)	Flow (l/hr)		Methane (%v/v)		Carbon Dioxide (%v/v)		Oxygen (%v/v)		Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)		Depth to water (m)	Base of Response Zone (m)	Free-Phase Product Level Top (m)	Groundwater Elevation (m AOD)	Notes
		Peak	Steady	Peak	Steady	Peak	Steady	Min	Steady								
Ambient Air Start (Calibration)																	
Ambient Air Finish (Calibration)																	
WS3		1.0	0.2	0.0	0.0	0.9	0.9	19.1	19.1				1.40	2.80			

Appendix H

GEOTECHNICAL TESTING RESULTS

TEST CERTIFICATE

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Tested in Accordance with: BS 1377-2: 1990

i2 Analytical Ltd
Unit 8 Harrowden Road
Brackmills Industrial Estate
Northampton NN4 7EB

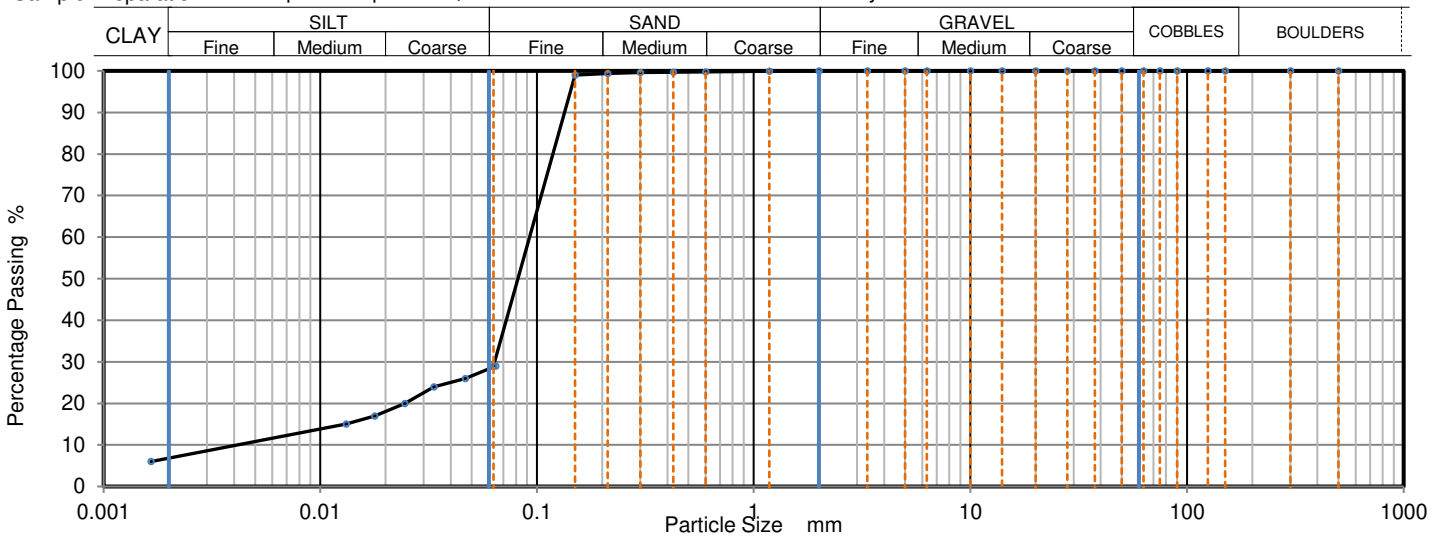
4041

Client:	Grange Geo Consulting Ltd	Client Reference:	R21071
Client Address:	43 Winchilsea Avenue, Newark, Notts, NG24 4AD	Job Number:	22-45038
		Date Sampled:	09/03/2022
		Date Received:	11/03/2022
Contact:	Andrew Hare	Date Tested:	18/03/2022
Site Address:	Surfleet	Sampled By:	Not Given

Testing carried out at i2 Analytical Limited, ul. Pionierow 39, 41-711 Ruda Slaska, Poland

Test Results:

Laboratory Reference:	2202167	Depth Top [m]:	0.50
Hole No.:	WS1	Depth Base [m]:	Not Given
Sample Reference:	Not Given	Sample Type:	D
Sample Description:	Brown clayey silty SAND		
Sample Preparation:	Sample was quartered, oven dried at 108.8 °C and broken down by hand.		



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
500	100	0.0644	29
300	100	0.0466	26
150	100	0.0334	24
125	100	0.0245	20
90	100	0.0178	17
75	100	0.0132	15
63	100	0.0017	6
50	100		
37.5	100		
28	100		
20	100		
14	100		
10	100		
6.3	100		
5	100		
3.35	100	Particle density	(assumed)
2	100	2.65	Mg/m3
1.18	100		
0.6	100		
0.425	100		
0.3	100		
0.212	99		
0.15	99		
0.063	29		

Sample Proportions	% dry mass
Very coarse	0
Gravel	0
Sand	71
Silt	22
Clay	7

Grading Analysis		
D100	mm	2
D60	mm	0.0928
D30	mm	0.0641
D10	mm	0.00416
Uniformity Coefficient		22
Curvature Coefficient		11

Uniformity Coefficient calculated in accordance with BS EN ISO 14688-2:2018

Note: Tested in Accordance with BS1377:Part 2:1990, clauses 9.2 and 9.5

Remarks:

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Signed:

Anna Dudzinska
PL Deputy Head of Reporting Team
for and on behalf of i2 Analytical Ltd

Date Reported: 29/03/2022

GF 100.21

TEST CERTIFICATE

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Tested in Accordance with: BS 1377-2: 1990

i2 Analytical Ltd
Unit 8 Harrowden Road
Brackmills Industrial Estate
Northampton NN4 7EB

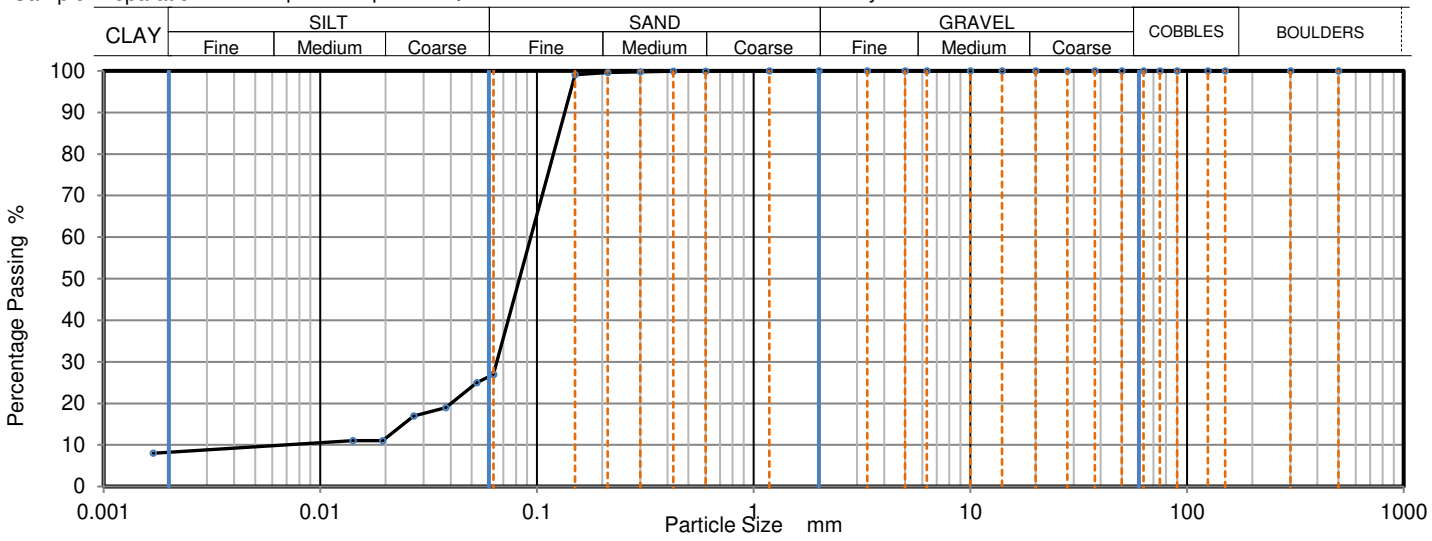
4041

Client:	Grange Geo Consulting Ltd	Client Reference:	R21071
Client Address:	43 Winchilsea Avenue, Newark, Notts, NG24 4AD	Job Number:	22-45038
		Date Sampled:	09/03/2022
		Date Received:	11/03/2022
Contact:	Andrew Hare	Date Tested:	18/03/2022
Site Address:	Surfleet	Sampled By:	Not Given

Testing carried out at i2 Analytical Limited, ul. Pionierow 39, 41-711 Ruda Slaska, Poland

Test Results:

Laboratory Reference:	2202168	Depth Top [m]:	1.50
Hole No.:	WS1	Depth Base [m]:	Not Given
Sample Reference:	Not Given	Sample Type:	D
Sample Description:	Brown clayey silty SAND		
Sample Preparation:	Sample was quartered, oven dried at 108.8 °C and broken down by hand.		



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
500	100	0.0630	27
300	100	0.0527	25
150	100	0.0379	19
125	100	0.0270	17
90	100	0.0194	11
75	100	0.0142	11
63	100	0.0017	8
50	100		
37.5	100		
28	100		
20	100		
14	100		
10	100		
6.3	100		
5	100		
3.35	100	Particle density	(assumed)
2	100	2.65	Mg/m3
1.18	100		
0.6	100		
0.425	100		
0.3	100		
0.212	100		
0.15	99		
0.063	27		

Sample Proportions	% dry mass
Very coarse	0
Gravel	0
Sand	74
Silt	18
Clay	8

Grading Analysis		
D100	mm	2
D60	mm	0.094
D30	mm	0.0657
D10	mm	0.00661
Uniformity Coefficient		14
Curvature Coefficient		6.9

Uniformity Coefficient calculated in accordance with BS EN ISO 14688-2:2018

Note: Tested in Accordance with BS1377:Part 2:1990, clauses 9.2 and 9.5

Remarks:

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Signed:

Anna Dudzinska
PL Deputy Head of Reporting Team
for and on behalf of i2 Analytical Ltd

Date Reported: 29/03/2022

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TEST CERTIFICATE

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Tested in Accordance with: BS 1377-2: 1990

i2 Analytical Ltd
Unit 8 Harrowden Road
Brackmills Industrial Estate
Northampton NN4 7EB

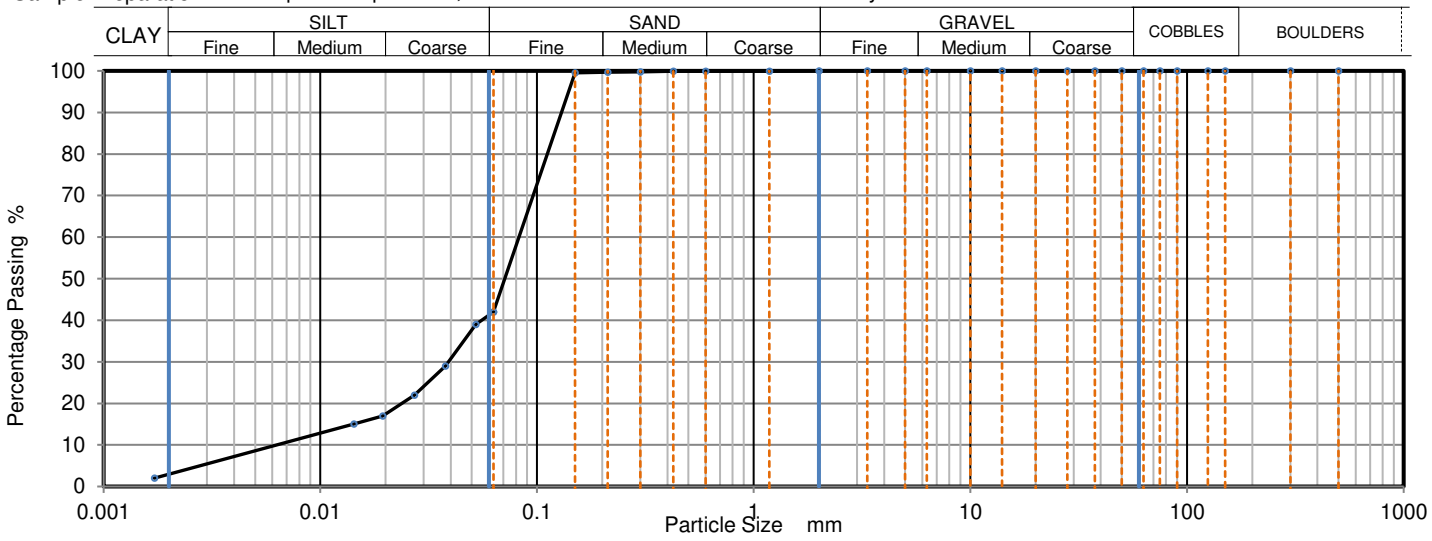
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Client:	Grange Geo Consulting Ltd	Client Reference:	R21071
Client Address:	43 Winchilsea Avenue, Newark, Notts, NG24 4AD	Job Number:	22-45038
		Date Sampled:	09/03/2022
		Date Received:	11/03/2022
Contact:	Andrew Hare	Date Tested:	18/03/2022
Site Address:	Surfleet	Sampled By:	Not Given

Testing carried out at i2 Analytical Limited, ul. Pionierow 39, 41-711 Ruda Slaska, Poland

Test Results:

Laboratory Reference:	2202169	Depth Top [m]:	0.80
Hole No.:	WS2	Depth Base [m]:	Not Given
Sample Reference:	Not Given	Sample Type:	D
Sample Description:	Brown slightly clayey very silty SAND		
Sample Preparation:	Sample was quartered, oven dried at 108.8 °C and broken down by hand.		



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
500	100	0.0630	42
300	100	0.0522	39
150	100	0.0378	29
125	100	0.0272	22
90	100	0.0194	17
75	100	0.0143	15
63	100	0.0017	2
50	100		
37.5	100		
28	100		
20	100		
14	100		
10	100		
6.3	100		
5	100		
3.35	100	Particle density	(assumed)
2	100	2.65	Mg/m3
1.18	100		
0.6	100		
0.425	100		
0.3	100		
0.212	100		
0.15	100		
0.063	42		

Sample Proportions	% dry mass
Very coarse	0
Gravel	0
Sand	58
Silt	39
Clay	3

Grading Analysis		
D100	mm	3.35
D60	mm	0.0829
D30	mm	0.0385
D10	mm	0.00631
Uniformity Coefficient		13
Curvature Coefficient		2.8

Uniformity Coefficient calculated in accordance with BS EN ISO 14688-2:2018

Note: Tested in Accordance with BS1377:Part 2:1990, clauses 9.2 and 9.5

Remarks:

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Signed:

Anna Dudzinska
PL Deputy Head of Reporting Team
for and on behalf of i2 Analytical Ltd

Date Reported: 29/03/2022

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TEST CERTIFICATE

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Tested in Accordance with: BS 1377-2: 1990

i2 Analytical Ltd
Unit 8 Harrowden Road
Brackmills Industrial Estate
Northampton NN4 7EB

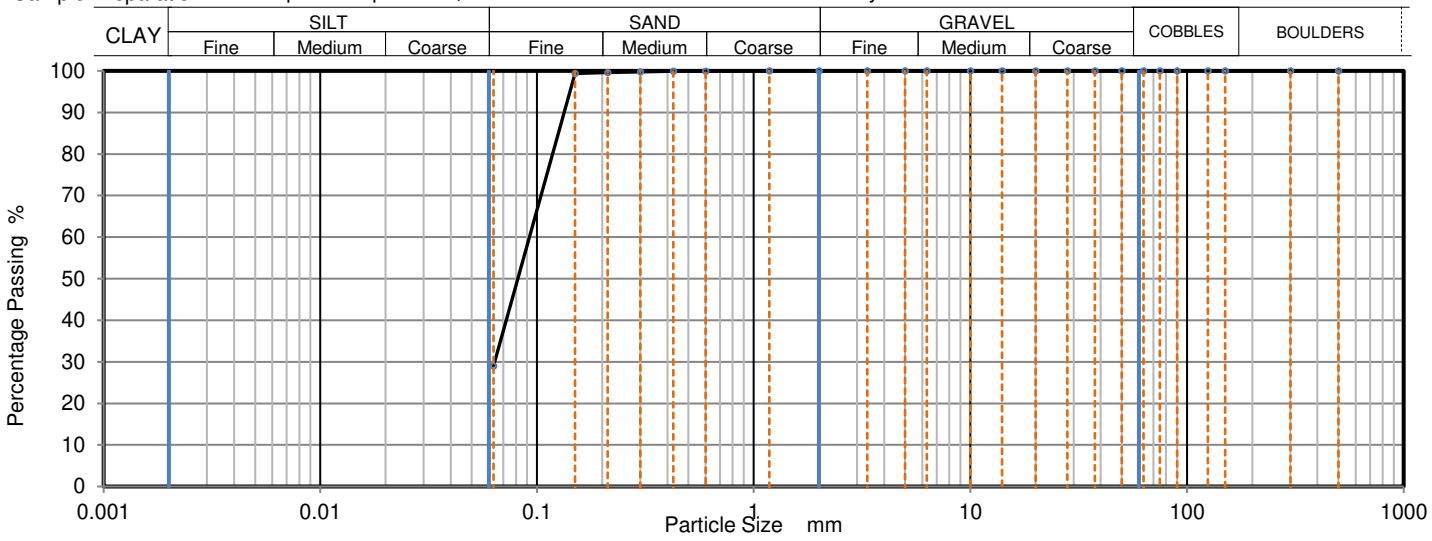
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Client:	Grange Geo Consulting Ltd	Client Reference:	R21071
Client Address:	43 Winchilsea Avenue, Newark, Notts, NG24 4AD	Job Number:	22-45038
		Date Sampled:	09/03/2022
		Date Received:	11/03/2022
Contact:	Andrew Hare	Date Tested:	18/03/2022
Site Address:	Surfleet	Sampled By:	Not Given

Testing carried out at i2 Analytical Limited, ul. Pionierow 39, 41-711 Ruda Slaska, Poland

Test Results:

Laboratory Reference:	2202170	Depth Top [m]:	1.20
Hole No.:	WS2	Depth Base [m]:	Not Given
Sample Reference:	Not Given	Sample Type:	D
Sample Description:	Brown clayey SAND		
Sample Preparation:	Sample was quartered, oven dried at 108.8 °C and broken down by hand.		



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
500	100		
300	100		
150	100		
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	100		
20	100		
14	100		
10	100		
6.3	100		
5	100		
3.35	100		
2	100		
1.18	100		
0.6	100		
0.425	100		
0.3	100		
0.212	100		
0.15	99		
0.063	30		

Sample Proportions	% dry mass
Very coarse	0
Gravel	0
Sand	70
Fines <0.063mm	30

Grading Analysis		
D100	mm	3.35
D60	mm	0.0918
D30	mm	0.0632
D10	mm	
Uniformity Coefficient		> 1.5
Curvature Coefficient		

Uniformity Coefficient calculated in accordance with BS EN ISO 14688-2:2018

Note: Tested in Accordance with BS1377:Part 2:1990, clause 9.2

Remarks:

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Signed: Dudzińska Anna

Anna Dudzinska
PL Deputy Head of Reporting Team
for and on behalf of i2 Analytical Ltd

Date Reported: 29/03/2022

GF 100.21

TEST CERTIFICATE

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

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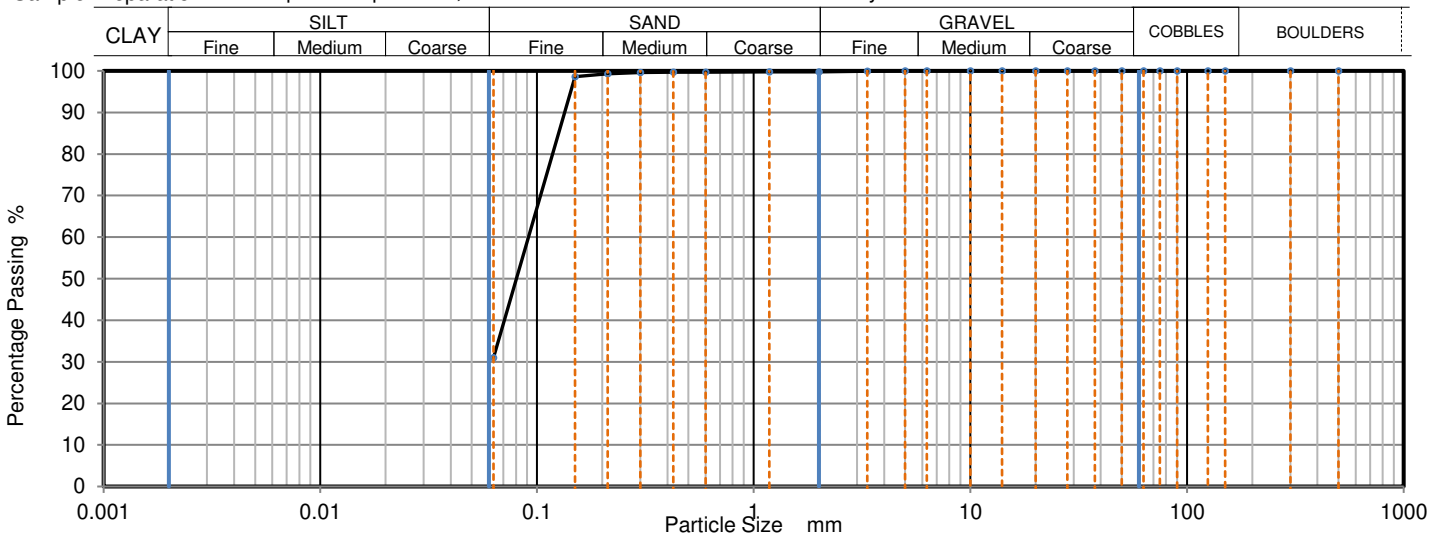
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Client:	Grange Geo Consulting Ltd	Client Reference:	R21071
Client Address:	43 Winchilsea Avenue, Newark, Notts, NG24 4AD	Job Number:	22-45038
		Date Sampled:	09/03/2022
		Date Received:	11/03/2022
Contact:	Andrew Hare	Date Tested:	18/03/2022
Site Address:	Surfleet	Sampled By:	Not Given

Testing carried out at i2 Analytical Limited, ul. Pionierow 39, 41-711 Ruda Slaska, Poland

Test Results:

Laboratory Reference:	2202171	Depth Top [m]:	0.60
Hole No.:	WS4	Depth Base [m]:	Not Given
Sample Reference:	Not Given	Sample Type:	D
Sample Description:	Brown clayey SAND		
Sample Preparation:	Sample was quartered, oven dried at 108.8 °C and broken down by hand.		



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
500	100		
300	100		
150	100		
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	100		
20	100		
14	100		
10	100		
6.3	100		
5	100		
3.35	100		
2	100		
1.18	100		
0.6	100		
0.425	100		
0.3	100		
0.212	99		
0.15	99		
0.063	31		

Sample Proportions	% dry mass
Very coarse	0
Gravel	0
Sand	69
Fines <0.063mm	31

Grading Analysis		
D100	mm	5
D60	mm	0.0913
D30	mm	
D10	mm	
Uniformity Coefficient		> 1.4
Curvature Coefficient		

Uniformity Coefficient calculated in accordance with BS EN ISO 14688-2:2018

Note: Tested in Accordance with BS1377:Part 2:1990, clause 9.2

Remarks:

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Signed: Dudzińska Anna

Anna Dudzinska
PL Deputy Head of Reporting Team
for and on behalf of i2 Analytical Ltd

Date Reported: 29/03/2022

GF 100.21

TEST CERTIFICATE

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Tested in Accordance with: BS 1377-2: 1990

i2 Analytical Ltd
Unit 8 Harrowden Road
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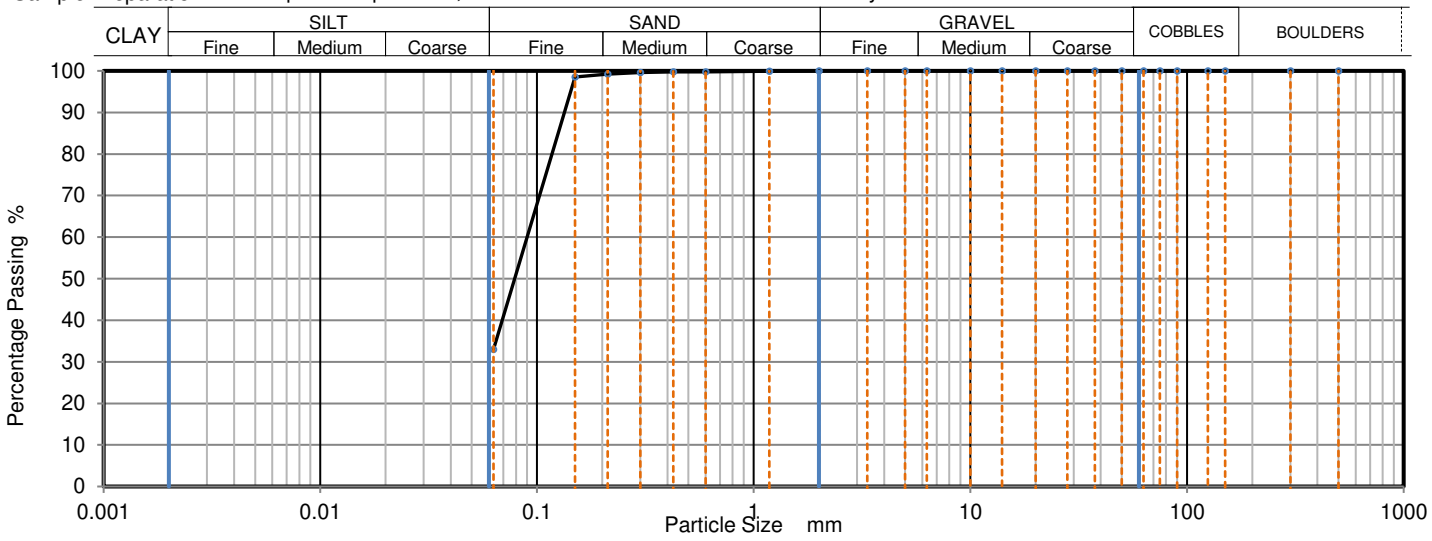
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Client:	Grange Geo Consulting Ltd	Client Reference:	R21071
Client Address:	43 Winchilsea Avenue, Newark, Notts, NG24 4AD	Job Number:	22-45038
		Date Sampled:	09/03/2022
		Date Received:	11/03/2022
Contact:	Andrew Hare	Date Tested:	21/03/2022
Site Address:	Surfleet	Sampled By:	Not Given

Testing carried out at i2 Analytical Limited, ul. Pionierow 39, 41-711 Ruda Slaska, Poland

Test Results:

Laboratory Reference:	2202172	Depth Top [m]:	0.50
Hole No.:	WS5	Depth Base [m]:	1.00
Sample Reference:	Not Given	Sample Type:	B
Sample Description:	Brown clayey SAND		
Sample Preparation:	Sample was quartered, oven dried at 106.0 °C and broken down by hand.		



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
500	100		
300	100		
150	100		
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	100		
20	100		
14	100		
10	100		
6.3	100		
5	100		
3.35	100		
2	100		
1.18	100		
0.6	100		
0.425	100		
0.3	100		
0.212	99		
0.15	99		
0.063	33		

Sample Proportions	% dry mass
Very coarse	0
Gravel	0
Sand	67
Fines <0.063mm	33

Grading Analysis		
D100	mm	3.35
D60	mm	0.0899
D30	mm	
D10	mm	
Uniformity Coefficient		> 1.4
Curvature Coefficient		

Uniformity Coefficient calculated in accordance with BS EN ISO 14688-2:2018

Note: Tested in Accordance with BS1377:Part 2:1990, clause 9.2

Remarks:

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Signed: Dudzińska Anna

Anna Dudzinska
PL Deputy Head of Reporting Team
for and on behalf of i2 Analytical Ltd

Date Reported: 29/03/2022

GF 100.21

TEST CERTIFICATE

DETERMINATION OF THE CALIFORNIA BEARING RATIO (CBR)

Tested in Accordance with: BS 1377-4: 1990: Clause 7

i2 Analytical Ltd
Unit 8 Harrowden Road
Brackmills Industrial Estate
Northampton NN4 7EB

UKAS TESTING 4041

Environmental Science

Client:	Grange Geo Consulting Ltd	Client Reference:	R21071
Client Address:	43 Winchilsea Avenue, Newark, Notts, NG24 4AD	Job Number:	22-45038
		Date Sampled:	09/03/2022
		Date Received:	11/03/2022
Contact:	Andrew Hare	Date Tested:	24/03/2022
Site Address:	Surfleet	Sampled By:	Not Given

Testing carried out at i2 Analytical Limited, ul. Pionierow 39, 41-711 Ruda Slaska, Poland

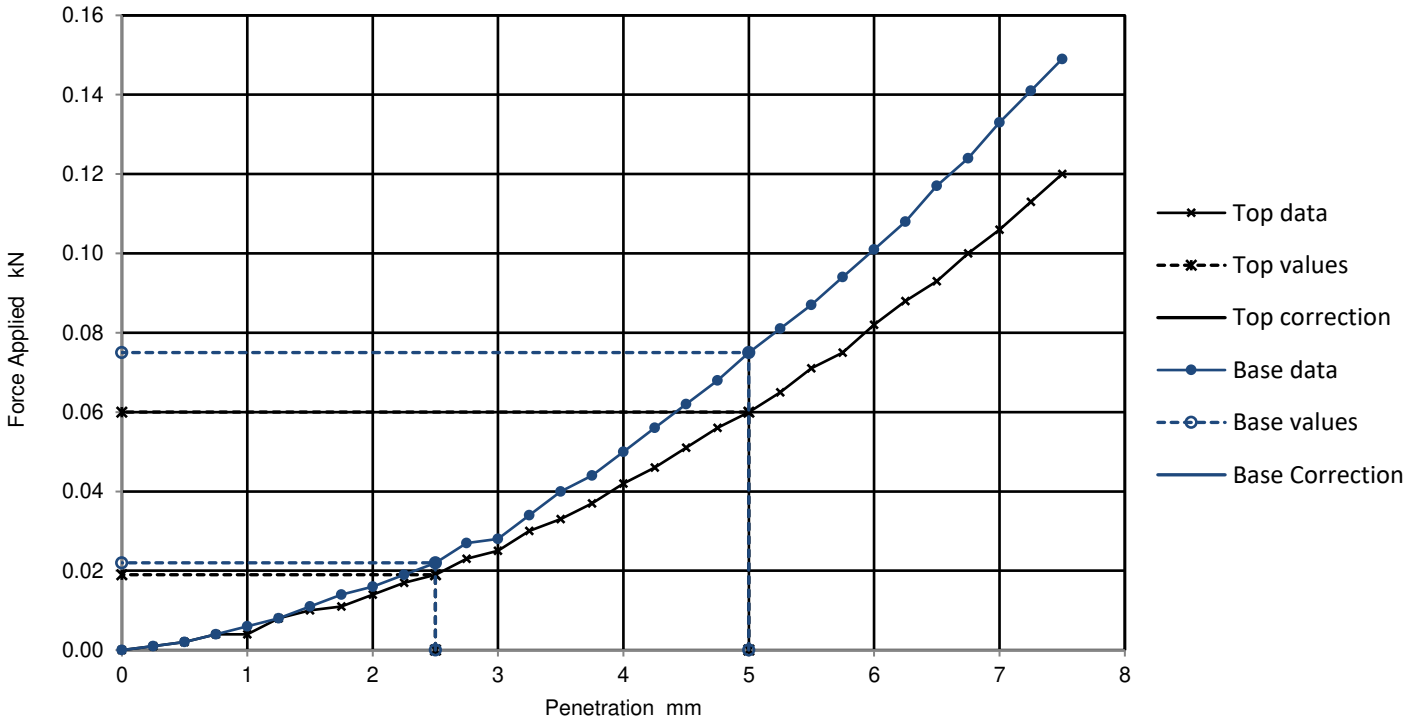
Test Results:

Laboratory Reference:	2202172	Depth Top [m]:	0.50
Hole No.:	WS5	Depth Base [m]:	1.00
Sample Reference:	Not Given	Sample Type:	B
Sample Description:	Brown clayey SAND		

Specimen Preparation:

Condition	Remoulded			Soaking details	Not soaked
Details	Recompacted with specified standard effort using 2.5kg rammer			Period of soaking	days
				Time to surface	days
				Amount of swell recorded	mm
Material retained on 20mm sieve removed		0	%	Dry density after soaking	Mg/m3
Initial Specimen details	Bulk density	1.85	Mg/m3	Surcharge applied	8 kg
	Dry density	1.45	Mg/m3		4.8 kPa
	Moisture content	27	%		

Force v Penetration Plots



Results

	Curve correction applied	CBR Values, %				Moisture Content %
		2.5mm	5mm	Highest	Average	
TOP	No	0.1	0.3	0.3		26
BASE	No	0.2	0.4	0.4		26

Remarks:

Test/ Specimen specific remarks:

Opinions and interpretations expressed herein are outside of the scope of the UKAS Accreditation. This report may not be reproduced other than in full without the prior written approval of the issuing laboratory. The results included within the report relate only to the sample(s) submitted for testing.

Signed: Dudzińska Anna

Anna Dudzinska
PL Deputy Head of Reporting Team
for and on behalf of i2 Analytical Ltd

Date Reported: 29/03/2022

GF 108.16

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Analytical Report Number : 22-45039

Project / Site name:	Surfleet	**Samples received on:**	11/03/2022
Your job number:	R21071	**Samples instructed on/ Analysis started on:**	11/03/2022
Your order number:		**Analysis completed by:**	24/03/2022
Report Issue Number:	1	**Report issued on:**	25/03/2022
Samples Analysed:	3 soil samples		

Signed:

Anna Goc
Technical Reviewer (Reporting Team)
For & on behalf of i2 Analytical Ltd.

Standard Geotechnical, Asbestos and Chemical Testing Laboratory located at: ul. Pionierów 39, 41 -711 Ruda Śląska, Poland.

Accredited tests are defined within the report, opinions and interpretations expressed herein are outside the scope of accreditation.

Standard sample disposal times, unless otherwise agreed with the laboratory, are :

soils - 4 weeks from reporting
leachates - 2 weeks from reporting
waters - 2 weeks from reporting
asbestos - 6 months from reporting

Excel copies of reports are only valid when accompanied by this PDF certificate.

Any assessments of compliance with specifications are based on actual analytical results with no contribution from uncertainty of measurement.
Application of uncertainty of measurement would provide a range within which the true result lies.
An estimate of measurement uncertainty can be provided on request.

This certificate should not be reproduced, except in full, without the express permission of the laboratory.
The results included within the report are representative of the samples submitted for analysis.

Analytical Report Number: 22-45039
Project / Site name: Surfleet

Lab Sample Number				2202173	2202174	2202175
Sample Reference				WS1	WS1	WS2
Sample Number				None Supplied	None Supplied	None Supplied
Depth (m)				0.50	1.50	0.80
Date Sampled				09/03/2022	09/03/2022	09/03/2022
Time Taken				None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**			
Stone Content	%	0.1	NONE	< 0.1	< 0.1	< 0.1
Moisture Content	%	0.01	NONE	20	21	20
Total mass of sample received	kg	0.001	NONE	0.4	0.4	0.4

General Inorganics

pH - Automated	pH Units	N/A	MCERTS	8.6	8.7	8.6
Total Sulphate as SO4	%	0.005	MCERTS	0.032	0.041	0.03
Water Soluble SO4 16hr extraction (2:1 Leachate Equivalent)	g/l	0.00125	MCERTS	0.035	0.028	0.038
Water Soluble Chloride (2:1) (leachate equivalent)	mg/l	0.5	MCERTS	2.1	3.5	2
Total Sulphur	%	0.005	MCERTS	0.017	0.034	0.014
Water Soluble Nitrate (2:1) as N (leachate equivalent)	mg/l	2	NONE	< 2.0	< 2.0	< 2.0

Heavy Metals / Metalloids

Magnesium (water soluble)	mg/kg	5	NONE	8.6	8.3	5.7
Magnesium (leachate equivalent)	mg/l	2.5	NONE	4.3	4.2	2.9

U/S = Unsuitable Sample I/S = Insufficient Sample

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Analytical Report Number : 22-45039
Project / Site name: Surfleet

* These descriptions are only intended to act as a cross check if sample identities are questioned. The major constituent of the sample is intended to act with respect to MCERTS validation. The laboratory is accredited for sand, clay and loam (MCERTS) soil types. Data for unaccredited types of solid should be interpreted with care.

Stone content of a sample is calculated as the % weight of the stones not passing a 10 mm sieve. Results are not corrected for stone content.

Lab Sample Number	Sample Reference	Sample Number	Depth (m)	Sample Description *
2202173	WS1	None Supplied	0.5	Brown loam and clay.
2202174	WS1	None Supplied	1.5	Brown loam and sand.
2202175	WS2	None Supplied	0.8	Brown loam and sand.

Analytical Report Number : 22-45039
Project / Site name: Surfleet

Water matrix abbreviations:
Surface Water (SW) Potable Water (PW) Ground Water (GW) Process Waters (PrW) Final Sewage Effluent (FSE) Landfill Leachate (LL)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Sulphate, water soluble, in soil (16hr extraction)	Determination of water soluble sulphate by ICP-OES. Results reported directly (leachate equivalent) and corrected for extraction ratio (soil equivalent).	In house method.	L038-PL	D	MCERTS
Magnesium, water soluble, in soil	Determination of water soluble magnesium by extraction with water followed by ICP-OES.	In-house method based on TRL 447	L038-PL	D	NONE
Moisture Content	Moisture content, determined gravimetrically. (30 oC)	In house method.	L019-UK/PL	W	NONE
pH in soil (automated)	Determination of pH in soil by addition of water followed by automated electrometric measurement.	In house method.	L099-PL	D	MCERTS
Stones content of soil	Standard preparation for all samples unless otherwise detailed. Gravimetric determination of stone > 10 mm as % dry weight.	In-house method based on British Standard Methods and MCERTS requirements.	L019-UK/PL	D	NONE
Total Sulphate in soil as %	Determination of total sulphate in soil by extraction with 10% HCl followed by ICP-OES.	In house method.	L038-PL	D	MCERTS
Total Sulphur in soil as %	Determination of total sulphur in soil by extraction with aqua-regia, potassium bromide/bromate followed by ICP-OES.	In house method.	L038-PL	D	MCERTS
Water Soluble Nitrate (2:1) as N in soil	Determination of nitrate by reaction with sodium salicylate and colorimetry.	In-house method based on Examination of Water and Wastewatern & Polish Standard Method PN-82/C-04579.08, 2:1 extraction.	L078-PL	W	NONE
Chloride, water soluble, in soil	Determination of Chloride colorimetrically by discrete analyser.	In house method.	L082-PL	D	MCERTS

For method numbers ending in 'UK' analysis have been carried out in our laboratory in the United Kingdom.
For method numbers ending in 'PL' analysis have been carried out in our laboratory in Poland.
Soil analytical results are expressed on a dry weight basis. Where analysis is carried out on as-received the results obtained are multiplied by a moisture correction factor that is determined gravimetrically using the moisture content which is carried out at a maximum of 30oC.

Unless otherwise indicated, site information, order number, project number, sampling date, time, sample reference and depth are provided by the client. The instructed on date indicates the date on which this information was provided to the laboratory.